SAN JOAQUIN TRIBUTARY SETTLEMENT PROCESS

Scientific Evaluation Process Demonstration – Stanislaus River Summary Report

May 2013

ESA PWA

THE ESSEX PARTNERSHIP

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SECTION 1
Introduction

This report describes a demonstration (pilot application) of the Scientific Evaluation Process (SEP) as a tool to support the San Joaquin Tributaries Settlement Process (Settlement Process). The purpose of the pilot was to:

1. demonstrate how the SEP approach works;
2. determine if the process could serve as a suitable fact-finding foundation for settlement discussions; and
3. provide recommendations for a refined process to support ecosystem restoration and water management decision-making.

The SEP, as described in more detail below, involves convening technical experts to systematically evaluate the efficacy of proposed conservation measures relative to defined goals and objectives. The process has also been adapted to evaluate flood management actions and could be adapted to other applications. For the purposes of this demonstration, the SEP was intentionally limited to focus only on the Stanislaus River and only on Fall-run Chinook salmon. Based on lessons learned from the pilot, the SEP may be further refined and applied more broadly to other tributary rivers and other management actions, such as those for water operations.

Following this introduction, Section 2 provides general background information on the SEP and how the process was specifically applied to the Stanislaus River. Section 3 provides a summary of findings from the evaluations of individual conservation measures and presents recommendations for potentially applying the SEP more broadly to encompass other tributaries and other management actions.

SECTION 2
Scientific Evaluation Process

The following sections provide a brief summary of how the Scientific Evaluation Process (SEP) is structured and how it was applied for the pilot exercise on the Stanislaus River. Ultimately the value of the SEP rests in its transparency and its commitment to rigor and written documentation. The process is intended to facilitate a dialog around what is known about various species and ecosystem processes and how proposed measures may positively or negatively impact them.

2.1 Background and Methodology

The Scientific Evaluation Process was initially developed to aid planning and decision making for ecosystem restoration projects in the Delta (DiGennaro, *et. al.*, 2012). The SEP was modified slightly from the Delta Regional Ecosystem Restoration Implementation Plan (DRERIP) process to fit this application on the Stanislaus River.

The SEP entails engaging teams of experts to work through a structured, step-by-step scientific examination of the potential positive and negative outcomes resulting from proposed restoration actions. The process has been used previously for the CALFED Ecosystem Restoration Program (ERP), the Bay Delta Conservation Plan (BDCP), in the South Delta, at Prospect Island, and on the Yuba River, and for evaluating flood management alternatives in the Central Valley. Detailed instructions describing each of the steps used in the evaluation process, as well as definitions for key terms, are provided in Appendix A.

The SEP is intended to rely on conceptual models describing the current scientific understanding of species populations and ecosystem processes. In the absence of conceptual models the process relies on existing studies and literature as the foundation for the evaluation.

Measures are evaluated independently to identify the effectiveness of each on its own merits. Ultimately, the Settlement Process will likely include an overall Conservation Strategy comprised of a suite of measures designed to work synergistically.

For the purposes of the pilot evaluation, the evaluation team focused strictly on ecological issues. The team did not consider other factors that may ultimately influence feasibility or priority setting, such as cost or socio-economic impacts. We provide recommendations in Section 3 for how the SEP can be enhanced to provide additional information on feasibility and applicability to key limiting factors of target species for potential use in full application to the Stanislaus and other tributaries.

2.2 Logic Chain Planning Framework and SMART Objectives

American Rivers and other Settlement Process participants have proposed using a planning framework referred to as the Logic Chain for developing and refining conservation measures. A critical step in the Logic Chain framework, as in any effective planning process, is the establishment of clear goals and objectives. For the purposes of testing the Logic Chain and SEP, the Settlement Process parties agreed to use the following goal and SMART Objectives for the Stanislaus River:

Goal: Double the population of fall-run Chinook salmon on the Stanislaus River.

SMART Objectives:

1. Increase abundance: Increase the Chinook salmon (fall-run) natural production 10-year running annual average to 22,000 adult fish. Natural production of anadromous fish in the Stanislaus River will be sustainable, on a long-term basis, and annual estimates includes escapement, harvest, and adjusted for any hatchery contributions.
2. Increase life history diversity:
    a. Life history strategy: Achieve the following distribution of life history strategies: 25% fry, 50% parr, and 25% smolt (USBR, unpublished data).
    b. Age structure: 15% two year; 60% three year; and 25% four year (Marston and Mesick 2007).
3. Increase the size/improve the condition of young salmon moving into the Delta (Baker and Morhardt 2001, USBR unpublished data).

The SEP functions as a step in the Logic Chain planning framework by providing for an objective, technical assessment of proposed conservation measures and their expected contribution to achieving the SMART objectives. SMART Objectives are designed to be Specific (S), Measureable (M), Achievable (A), Relevant (R), and Time bound (T).

2.3 Stanislaus River Pilot Evaluation

A team of 12 experts was selected and convened to evaluate seven example conservation measures as a demonstration of how the process might be applied to the San Joaquin Tributary Settlement Process. Team members were selected based on their expertise relative to the specific ecological issues associated with the draft conservation measures, as well as their familiarity with the Stanislaus River. A listing of evaluation team members is provided in **Table 1** below.

An initial workshop was held on March 27, 2013 to introduce the evaluation team to the SEP. A two-day workshop was held on April 9 and 10, 2013 to further orient the team to the SEP, discuss the draft conservation measures, and work through the evaluation steps for each conservation measure. At the end of the workshop, three-member teams were created to complete a standard evaluation worksheet for each of the conservation measures. A lead author was assigned to each team. A listing of the team leaders and who worked on which conservation measure are provided in the evaluation worksheets (see Appendix B).

A follow-up half-day workshop was held on May 2, 2013 to review and discuss draft evaluation worksheets. Refinements to the worksheets were made following the workshop. To provide a sort of peer review, each draft evaluation worksheet was subsequently reviewed by one or more experts that had not worked on the specific, three-person evaluations beyond participating in the group discussions during the two workshops.

TABLE 1
SCIENTIFIC EVALUATION TEAM MEMBERS

Participant	Agency/Organization
Rachel Barnett-Johnson	US Bureau of Reclamation
John Cain	American Rivers
Andrea Fuller	FISHBIO (on behalf of SJTA)
Rene Henery	Trout Unlimited
Jeanette Howard	The Nature Conservancy
Josh Israel	US Bureau of Reclamation
Michael Martin	Merced River Conservation Committee
Ramon Martin	US Fish and Wildlife Service
Alison Weber-Stover	The Bay Institute
John Wooster	National Marine Fisheries Service
Ron Yoshiyama	UC Davis (on behalf of San Francisco Public Utilities Commission)
Julie Zimmerman	US Fish and Wildlife Service

2.4 Conservation Measures Evaluated

Seven draft, example conservation measures were evaluated. The measures were selected by the Technical Workgroup as representative measures that would be worth examining for the purposes of the demonstration project. **Table 2** below provides a listing and brief description of the seven measures that were evaluated. Full descriptions of the measures, along with clarifying assumptions made by the team are provided at the beginning of each completed evaluation worksheet provided in Appendix B. Only those outcomes that were drafted and found relevant to a conservation measure are included in the respective evaluation worksheets in Appendix B.

Conservation measures were evaluated independent from each other. No attempt was made in this demonstration project to look at the combined effects of combinations of actions.

TABLE 2
CONSERVATION MEASURES EVALUATED

Conservation Measure	Brief Descriptions
CM1 – Gravel Augmentation	Increase and enhance Chinook salmon spawning habitat by adding 50,000 cubic yards of gravel and maintaining no net loss of gravel thereafter. Add cleaned spawning sized gravels to degraded areas of the salmonid spawning reach in the lower Stanislaus River between Goodwin Dam (RM 58.4) and Orange Blossom Bridge (RM 46.9).
CM2 – Predator Suppression	Reduce predation losses of outmigrating juvenile Chinook salmon in the lower Stanislaus River between Oakdale (RM 40.1) and Caswell (RM 8.6). Implement a predator suppression program to reduce non-native predator abundance by 5%-10% annually.
CM3 – Cold Water Refugia	Create cold water refugia every five miles between Ripon and Mossdale by pumping cool groundwater (60 degrees F or 15.6°C) from the shallow aquifer into refugia zones designed with appropriate cover (large woody debris) to reduce mixing and limit predation.
CM4 –Water Temperature Reduction	Meet CDFW proposed water quality standard of 15°C (59°F) to the confluence (seven day average daily maximum [7DADM] values) for smoltification during May 15 through June 15 by providing up to 1,000 cfs daily in addition to existing flow.
CM5 – Lower SJR Floodplain	Restore 5,000 acres of floodplain habitat along the Lower San Joaquin between Vernalis and Mossdale by removing levees and adding large wood debris and/or raising the channel invert to reduce channel capacity, and increasing releases from New Melones to 3,500 cfs for 14-28 days in 80 percent of years.
CM6 – Floodplain Inundation	Inundate 300 acres of off-channel rearing habitat between Knights Ferry and Ripon for 14 – 28 consecutive days during February 1st to May 31st by providing pulse flows of 3,500 cfs during Dry, Below Normal, Above Normal, and Wet years.
CM7 – Create Floodplain and Side Channel Rearing Habitat	Restore 100 acres of floodplain and side channel habitat in the Ripon to Knights Ferry reaches that will inundate more frequently. Side channels will be designed to inundate annually (even during critically-dry years) during spring flows and will not be perennially inundated. Floodplain restoration includes cut and fill to lower elevation of existing floodplain and raise channel surface on existing bed to create seasonally inundated habitats.

SECTION 3
Summary of Findings

One of the primary purposes of conducting the pilot evaluation was to determine if the process could serve as a suitable fact-finding foundation for settlement discussions, and if so how it might be refined to better serve this purpose. The following presents overall findings from the demonstration to aid in these determinations.

Two types of findings are presented; (1) process findings, and (2) preliminary evaluation results. The process findings are intended to help in refining the process if parties decide to pursue a full-scale application, including a more complete evaluation of the Stanislaus River and incorporation of additional tributaries. Initial evaluation results are provided here to illustrate how scores can be compiled to aid decision making. These results are preliminary and subject to further review and refinement. They should not be used to make any definitive determinations or conclusions regarding the merits of specific conservation measures without a more thorough review.

3.1 Process Findings

1. **The process could be improved by making it more proactive**. The SEP approach developed for DRERIP was designed to reactively evaluate (or vet) proposed restoration measures. With the San Joaquin Tributaries Settlement Process, there is an opportunity to utilize the functionality of the SEP to design more effective conservation measures "up front," in a more proactive way (as outlined below). Considerable time was spent in the pilot evaluation trying to better understand the proposed measures and developing clarifying assumptions needed to evaluate the measures. Better designed and described actions would save time, provide a basis for more-accurately estimating the costs of the actions, and would allow for an assessment of how they would influence the population (via population modeling) and thus meet goals.
2. **An analysis of limiting factors could make the process more effective.** One of the strengths of the Logic Chain process is its reliance on development of SMART objectives which are linked to the identification of key stressors and other limiting factors. Additional information on limiting factors would help inform development of the SMART objectives/stressor reduction targets, and support more-targeted, effective conservation measures. Similarly, while not necessary for conducting an evaluation, population modeling would help appropriately size the conservation measures to generate a population-level response adequate to meet stated goals. In the original DRERIP process, this type of information was contained in species and ecosystem conceptual models which formed the basis for the evaluations. There are available tools and a number of ongoing species life-cycle modeling efforts underway in the system. Using these tools and tapping into these ongoing efforts could save time and resources. Further, they could help gain collaboration with other efforts (e.g., NOAA recovery planning) and increase the viability of the settlement process.

3. **A similar approach could be applied to water management actions.** The San Joaquin Tributaries Settlement Process will involve development of both ecosystem and water management actions to achieve settlement goals. Development of a transparent, rigorous water management evaluation process that uses a similar approach and terminology would facilitate negotiations and the identification of the most effective measures, or combination of measures. A transparent and benefits- (outcomes-) based process is important because of the varied level of understanding of the complexity of water operations modeling and the need for all parties in the settlement to feel an agreeable level of understanding of the ultimate outcomes.
4. **Evaluation Team availability is critical**. One of the keys to successfully using the SEP is having the right technical experts available, and having enough of their time dedicated to the effort to conduct the necessary research and writing. If the SEP is applied more broadly in support of the Settlement Process, it will be critical to allocate adequate technical staff time to the effort.
5. **Need sufficient time for team review**. Internal team review during the demonstration project was cut short due to time constraints. For future evaluations, it will be important to ensure that adequate time is provided for the full team to review and discuss the worksheets and associated scoring as a group. It is efficient to work in smaller groups, but there needs to be enough time for the full team to deliberate to ensure consistency between measures and to bring the experience of all the team members to each measure. Ensure that the team has the opportunity to evaluate all the measures to the same extent.
6. **Scale and Magnitude scores should be reviewed carefully.** Several issues arose during the evaluation associated with Scale and the Magnitude of outcomes. In some cases, while the relative change caused by an action was expected to be large (e.g. tripling of rearing habitat), the absolute increase was expected to be relatively small (e.g. increase of 100 acres), and the impact at a population level was uncertain. These issues were compounded by: (1) unclear descriptions of the measures; (2) limited foundational information regarding existing conditions, action feasibility, and limiting factors; (3) the fact that several of the team members were new to the process; and (4) limited time to work through differences of interpretation. All the Scale and Magnitude scores should be carefully reviewed for consistency, and should be reconsidered if additional work is done on limiting factors, action refinement, and population modeling. Better development of the conservation measures with additional technical rigor would have eliminated many of these issues. Similarly, now that the team is familiar with the process, there should be efficiencies going forward if additional evaluations are conducted using the same team.
7. **Standard Outcomes could be modified** – Several modification to the standard SEP outcomes were suggested during the pilot evaluation, including:
    a. Integrate new outcomes focused on gravel-bedded river areas.
    b. Change outcome P20 to growth rate, rather than size.
    c. Consider combining outcomes P9, P11 and P16.
    d. Add a new outcome related to "increase abundance" so that teams are directly scoring all three of the SMART objectives outlined in the "strawman", developed by the Technical Workgroup for this demonstration. SMART objectives should be revised as necessary to address the limiting factors.
8. **Objectives could be scored directly**. Further revisions to the SEP should look at opportunities to evaluate the contribution to achieving specific objectives more directly. This could be done by scoring objectives as outcomes, or evaluating outcomes that are explicitly linked to a given objective. This could save time and would allow for a better integration of the results into the Logic Chain framework.

3.2 Preliminary Evaluation Results

The following presents a brief summary of preliminary results from the evaluation of individual draft conservation measures. As noted above, these findings are provided for illustrative purposes. Additional review and analyses should be conducted before utilizing these results to inform the settlement process.

Evaluation results as presented here should be viewed as preliminary. It was difficult for the teams to evaluate some of the actions due to a lack of specificity regarding the measures and/or a lack of information on key limiting factors driving the population of Fall-run Chinook salmon in the Stanislaus River. The teams were also provided very limited time to review the draft worksheets and there was no opportunity for the team to walk through the drafts together as a group. Lastly, the measures evaluated, by design only represent a subset of the various conservation measures that might be considered.

Completed evaluation worksheets for each measure, including the rationales behind the results are contained in Appendix B. The detailed worksheets include the specifics regarding individual measures and expected species outcomes. The worksheets also contain a list of data gaps, future research needs, and suggestions for potential refinements to the conservation measures themselves.

Table 3 below provides a summary listing of the magnitude and certainty scores for each outcome by conservation measure. Rationales for these scores are provided in the evaluation worksheets contained in Appendix B. Table 3 also shows a Worth/Risk rating (High, Medium, Low) for each outcome derived from combining the magnitude and certainty scores according to the conversion tables shown in Appendix A. The ratings shown for positive outcomes reflect Worth. The ratings shown for negative outcomes reflect Risk.

Table 4 provides a roll-up summary of the Worth and Risk ratings for each conservation measure. Total Worth reflects an averaging of the positive outcome scores. Total Risk reflects the highest recorded Risk rating across the outcomes.

Preliminary results as shown in Tables 3 and 4 suggest that the conservation measures fall into the following three groupings:

<u>High Worth</u>
CM 5 – Lower SJR Floodplain Habitat
CM 7 – Create Floodplain and Side Channel Rearing Habitat

<u>Medium Worth</u>
CM 1 - Gravel Augmentation
CM 2 - Predator Suppression
CM 4 – Water Temperature Reduction
CM 6 - Floodplain Inundation

<u>Low Worth</u>
CM 3 - Cold Water Refugia

All of the measures are expected to have a medium risk, with the exception of CM 1 (Low Risk) and 4 (High Risk). The High Risk rating for CM 4 is associated with concern that the measure may increase the number of juveniles that suffer mortality on their migration through the Lower San Joaquin River and Delta. The certainty associated with this outcome is relatively low (2).

The evaluation team did not try to link the outcome scores directly to the SMART objectives, but some of the outcomes do reflect objectives, specifically outcomes P20 and P21 which address life history diversity and fish size. More work could be done in future evaluations to more closely link the results to SMART objectives.

TABLE 3
SUMMARY OUTCOME SCORES BY CONSERVATION MEASURE

	CM1 Gravel Augmentation			CM2 Predator Control			CM3 Cold Water Refugia			CM4 Temperature Reduction			CM5 Spring Floodplain Habiat			CM6 Inundated Floodplain			CM7 Side Channel Rearing Habitat		
Outcome	**M**	**C**	**W/R**	**M**	**C**	**W/R**	**M**	**C**	**W/R**	**M**	**C**	**W/R**	**M**	**C**	**W/R**	**M**	**C**	**W/R**	**M**	**C**	**W/R**
P1 - Increased habitat extent and connectivity	2	3	M	2	2	M	2	1	L	4/3	2	H/M	4	3	H	3	3/2	H/M	3/2	3	H/M
P2 - Additional spawning habitat	4/3	3	H	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
P3 - Additional rearing habitat	3	2	M	2	2	M	1	1	L	3	2	M	4	4	H	3	2	M	3	3	H
P4 - Potential for expanded spatial distribution into formerly (historically) occupied habitat areas	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	2	2	M	4	3	H	3	2	M	3	3	H
P5 - Increased upstream migration opportunities	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	1	4	M	n/a	n/a	n/a	n/a	n/a	n/a
P6 - Reduced habitat for non-native fish	2	2	M	n/a	n/a	n/a	n/a	n/a	n/a	3	3/2	H/M	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
P7 - Increased establishment of woody riparian vegetation providing shaded channel habitat, increased channel margin complexity, and export of large woody debris (LWD)	2	3	M	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	2	2	M	2	3	M	3/2	3	H/M
P8 - Increased establishment of emergent vegetation providing high quality rearing habitat	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	3	3	H	2	3	M	2/1	3/2	M/L
P9 - Reduced periodic low dissolved oxygen events	3/2	2	M	n/a	n/a	n/a	2	1	L	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
P10 - Increased delivery of readily-suspendable sediments providing increased turbidity downstream, improved habitat conditions, and greater feeding success, and reduced predation	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	1	3	M	2	2	M	2	2	M
P11 - Contributes to conditions with water te mperatures appropriate for salmonid migration, spawning, incubation, and rearing	3	2	M	n/a	n/a	n/a	2	1	L	3	2	M	4	3	H	2	3	M	n/a	n/a	n/a
P12 - Increased production and local availability of aquatic food resources (POM, phytoplankton, zooplankton, small fish, etc)	2	3	M	2	3	M	n/a	n/a	n/a	n/a	n/a	n/a	4	4	H	2	3	M	3/2	2	M
P13 - Increased production of terrestrial invertebrates put into the aquatic ecosystem for rearing covered fish	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	2	3	M	2	3	M	3	3	H
P14 - Food resources produced on the restored habitat will be exported and contribute to food availability in downstream aquatic areas. (Note: food resources could include organic carbon, phytoplankton, zooplankton, and other organisms)	2	3	M	n/a	n/a	n/a	n/a	n/a	n/a	3	2	M	4	2	H	n/a	n/a	n/a	3/2	2	M
P15 - Increased or decreased nutrients (NPK, etc)	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	2	4	H	n/a	n/a	n/a	2	2	M
P16 - Decrease mortality from excessive temperatures	2	3	M	n/a	n/a	n/a	2	1	L	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
P17 - Reduced predation mortality (i.e. due to striped bass, black bass, and other non-native predatory species)	2	2	M	2	2	M	n/a	n/a	n/a	n/a	n/a	n/a	2	3	M	2	2	M	3/2	2	M
P18 - Increased survival of out-migrating juveniles by providing migration route with lower predation	n/a	n/a	n/a	2	2	M	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	2	3/2	M
P19 - Reduced sublethal effects (genetic, tissue/organ damage, development, reproductive, growth, and immune) of mercury on covered fish species	2	2	M	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
P20 - Increase juvenile chinook salmon size at emigration	2	2	M	n/a	n/a	n/a	n/a	n/a	n/a	3	2	M	4	4	H	-	-	-	3	3	H
P21 - Increase life history diversity (or diversity of outmigration)	2	2	M	2	2	M	2	1	L	3	2	M	3	2	M	-	-	-	3	3	H
P22 - Increase survival of Chinook salmon during outmigration	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	3	2	M	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
N1 - Increased habitat for non-native predators/competitors to covered species	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	2	2	N	n/a	n/a	n/a	2	3	M
N2 - Establishment of undesirable invasive species that will alter habitat conditions	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	2	3	M	n/a	n/a	n/a
N3 - Restoration site creates a population sink for covered fish species (Provides rearing habitat that becomes a one-way trip to entrainment or predation?)	n/a	n/a	n/a	n/a	n/a	n/a	2	2	M	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
N4 - Increased stranding or entrainment mortality	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	2	2	M	n/a	n/a	n/a	2	3	M
N5 - Potential for increased mercury methylation, local bioaccumulation and impact on covered species (on floodplain and downstream)	1	4	L	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	2	3	M	-	-	-	n/a	n/a	n/a
N6 - Delayed passage and increased poaching	n/a	n/a	n/a	2	3	M	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
N7 - Increased percentage (an absolute number) of juveniles that suffer mortality on their migration through the Lower San Joaquin River and Delta	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	3	2	H	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

TABLE 4
SUMMARY WORTH AND RISK SCORES BY CONSERVATION MEASURE

	SCORING (see table 3 and 4 in Scoring Criteria for Evaluating Strategies)			
Conservation Measure	**WORTH**		**RISK**	
(1) Gravel Augmentation	Med	2.1	Low	1.0
(2) Predator Control	Med	2.0	Med	2.0
(3) Cold Water Refugia	Low	1.0	Med	2.0
(4) Temperature Reduction	Med	2.2	High	3.0
(5) Spring Floodplain Habitat	High	2.6	Med	2.0
(6) Inundated Floodplain	Med	2.2	Med	2.0
(7) Side Channel Rearing Habitat	High	2.5	Med	2.0
	Med	**2.1**	**High**	**3.0**

Scoring Weight:
Low 1 – 1.5
Med 1.5 – 2.5
High 2.5 - 3

Appendix A
SEP Instructions

ESA PWA

APPENDIX A

Demonstration of the Scientific Evaluation Process: Stanislaus River

Instructions

Key assumptions:

- For the purposes of this demonstration, the scope of the evaluation area is restricted to only the Stanislaus River. (Later, the conservation measures on the individual rivers will likely be evaluated relative to the Stanislaus, Merced, and Tuolumne Rivers).
- For the purposes of this demonstration, the existing hydrologic operational regime is assumed as a baseline from which to consider the conservation measures.
  - The data used to assess the timing, frequency, and duration of ecologically-significant flows levels is for the period 1992-2010, as recorded at USGS gage # 11302000 (Stanislaus River below Goodwin Dam, near Knights Ferry, CA).
  - Any observations on how an alternative flow regime may influence the conservation measures should be noted by the evaluation team.
- Assessment of the conservation measures assumes the restoration action is completed, and any planted vegetation is mature and "functional".

Step 1: Review the Scale

Review the relative scale of the conservation measure based on the following criteria and in relation to the other conservation measures. The purpose of establishing scale is to assist with determining the magnitude of effect on the ecosystem.

Large: Broad spatial extent, significant duration and/or frequency, and/or major reversal compared to existing conditions.

Medium: Moderate spatial extent, moderate duration and/or frequency, and/or moderate change compared to existing conditions.

Small: Small acreage, short duration or only occasionally, and/or small change compared to existing conditions.

Step 2: Score Magnitude and Certainty of Potential Positive and Negative Ecological Outcomes

Using the relevant source materials, identify and score the expected magnitude and certainty of the identified positive and negative ecological outcomes.

- Record the magnitude and certainty for each outcome on the evaluation worksheet. Use the definitions and criteria listed at the end of these instructions to guide the scoring determination.
- Document a rationale for how scores for magnitude and certainty were arrived at, including citation of specific model sections and page numbers, and/or additional information used in the rationale section.
- After developing initial scores, consider and add any notes related to how an alternative flow regime on the Stanislaus River may influence key habitats and species outcomes and associated scoring. Include any suggestions for specifics on the timing, frequency, duration and magnitude of any flow component that may be beneficial (or adverse) to the target species as related to this conservation measure.

Step 3: Identify Data Gaps and Potential Refinements for Future Planning

Based on the evaluation process, for each conservation measure reflect back on the evaluation and identify any important new ideas or understandings, any identified data gaps, or future analysis or research needs. This includes additional (or new) analysis necessary to resolve outstanding uncertainty and noting any potential to change assumptions or the configuration of the conservation measure (or combinations/interactions of the conservation measures) to increase the worth/decrease the risk of potential implementation. Record ideas in the appropriate boxes on the evaluation worksheet.

Definitions, Criteria and Conversion Matrices

The following definitions, criteria, and conversion matrices, are provided to aid the Scientific Evaluation Process. Some of the definitions pertain to terms used in available conceptual models, such as the Driver-Linkage-Outcome framework. Other definitions relate directly to completion of the Scientific Evaluation Process worksheets.

The terms ***scale, magnitude,*** and ***certainty*** are Scientific Evaluation Process terms used to characterize the cumulate "path" or "chain" found between the restoration in each conservation measure being evaluated and each outcome being considered within the evaluation. The terms ***importance, predictability,*** and ***understanding*** are used in some conceptual models and are reflected in scoring criteria to characterize individual linkages (depicted as arrows in the models) between a driver and an outcome. The terms <u>pertain to specific processes</u> or mechanisms *within a given model* (e.g. how important is the supply of organic matter to mercury methylation?). The graphical forms of the conceptual models apply line color, thickness, and style to represent these three terms. See the following link for more information regarding the DRERIP conceptual models, some of which are applicable to portions of the Stanislaus River: http://www.dfg.ca.gov/ERP/conceptual_models.asp. The terms ***worth*** and ***risk*** are Scientific Evaluation Process terms that combine considerations of ***magnitude*** and ***certainty*** to assess the consequences of an action.

> ***Certainty*** - Certainty describes the likelihood that a given conservation measure will achieve a certain Outcome. Certainty considers both the predictability and understanding of

linkages in the DLO pathway from the action to the outcome. Generally, high importance-low predictability linkages drive the scoring; it is important to ensure that certainty is not unduly weighted by a comparatively low-importance, albeit low-predictability linkage.

Drivers – Drivers are physical, chemical, or biological forces (natural or artificial) that have a large influence on the system or species of interest. Drivers may be uncontrolled (i.e., not under management control or influence) or managed (i.e., under direct management control or influence).

Importance - The degree to which a linkage controls the outcome *relative to* other drivers and linkages affecting that same outcome. Our understanding of processes should encompass all identifiable drivers, linkages and outcomes, but the concept of "importance" recognizes that some are more important than others in determining how the system works. If a driver is potentially more important under particular environmental conditions, the evaluation should acknowledge the maximum level of importance of this driver with narrative describing the range of spatial and temporal conditions associated with this driver.

Linkages – Linkages are cause-and-effect relationships between drivers and outcomes. In some conceptual models they are depicted by arrows.

Magnitude – Magnitude assesses the size or level of the outcome, either positive or negative, in terms of population or habitat effects on a given species. Magnitude is not the same as the scale of the action; however, higher magnitude scores require consideration of scale.

Outcomes - Outcomes are environmental- or species-response variables that are predicted to be influenced by the drivers through the associated linkages. Outcomes may be physical, chemical, or biological.

Predictability - The degree to which the performance or the nature of the outcome can be predicted from the driver. Predictability seeks to capture the variability in the driver-outcome relationship. Predictability can encompass temporal or spatial variability in conditions of a driver (e.g., suspended sediment concentration or grain size), variability in the processes that link the driver to the outcome (e.g., sediment deposition or erosion rate as influenced by flow velocity), or our level of understanding about the cause-effect relationship (e.g., magnitude of sediment accretion inside vs. outside beds of submerged aquatic vegetation). Any of these forms of variability can lead to difficulty in predicting change in an outcome based on changes in a driver.

Risk - Combines the ***magnitude*** and ***certainty*** of negative outcomes to convey the overall degree of risk associated with implementing a conservation measure. Note that the term "risk" here applies to the *risk of the decision*, not the degree of the potential impact. High magnitude, high certainty outcomes are considered less "risky" than high magnitude, low certainty outcomes because it is assumed that the ability to manage and mitigate for the former is greater due to the high certainty (i.e. greater understanding and knowledge).

Scale - Scale addresses temporal and spatial considerations, quantity and/or degree of change contained within the Action.

Understanding – A description of the known, established, and/or generally agreed upon scientific understanding of the cause-effect relationship between a single driver and a single outcome. Understanding may be limited due to lack of knowledge and information or due to disagreements in the interpretation of existing data and information; or because the basis for assessing the understanding of a linkage or outcome is based on studies done elsewhere and/or on different organisms, or conflicting results have been reported. Understanding should reflect the degree to which the conceptualization of the system does, in fact, represent the system.

Worth - Combines the ***magnitude*** and ***certainty*** of positive outcomes to convey the cumulative "value" of a conservation measure toward achieving an outcome.

Scientific Evaluation Process Scoring Criteria

The following tables should be used to inform ***magnitude and certainty*** scores. These entail looking holistically at the cumulative value (positive or negative) of an outcome.

TABLE 1
CRITERIA FOR SCORING MAGNITUDE OF ECOLOGICAL OUTCOMES (POSITIVE OR NEGATIVE)

4 - High: expected sustained major population level effect, e.g., the outcome addresses a key limiting factor, or contributes substantially to a species population's natural productivity, abundance, spatial distribution and/or diversity (both genetic and life history diversity) or has a landscape scale habitat effect, including habitat quality, spatial configuration and/or dynamics. Requires a large-scale.
3 - Medium: expected sustained minor population effect or effect on large area (regional) or multiple patches of habitat. Requires at least a medium-scale.
2 - Low: expected sustained effect limited to small fraction of population, addresses productivity and diversity in a minor way, or limited spatial (local) or temporal habitat effects.
1 - Minimal: Existing literature indicates little effect.

TABLE 2
CRITERIA FOR SCORING CERTAINTY OF ECOLOGICAL OUTCOMES (POSITIVE OR NEGATIVE)

4 - High: Understanding is high (based on peer-reviewed studies from within system and scientific reasoning supported by most experts within system) and nature of outcome is largely unconstrained by variability (i.e., predictable) in ecosystem dynamics, other external factors, or is expected to confer benefits under conditions or times when available information indicates greatest importance.
3 - Medium: Understanding is high but nature of outcome is dependent on other highly variable ecosystem processes or uncertain external factors or understanding is medium (based on peer-reviewed studies from outside the system and corroborated by non peer-reviewed studies within the system) and nature of outcome is largely unconstrained by variability in ecosystem dynamics or other external factors.
2 - Low: Understanding is medium and nature of outcome is greatly dependent on highly variable ecosystem processes or other external factors or understanding is low (based on non peer-reviewed research within system or elsewhere) and nature of outcome is largely unconstrained by variability in ecosystem dynamics or other external factors.
1 - Minimal: Understanding is lacking (scientific basis unknown or not widely accepted), or understanding is low and nature of outcome is greatly dependent on highly variable ecosystem processes or other external factors.

Conversion Matrices

The following two matrices are designed to combine scores for magnitude and certainty to develop overall values for Worth and Risk.

TABLE 3
CONVERSION MATRIX FOR DETERMINING WORTH FROM THE CRITERIA SCORES FOR POSITIVE OUTCOMES

Is It Worthwhile?
Combining Magnitude And Certainty

Magnitude \ Certainty	1	2	3	4
1	Low	Low	Med	Med
2	Low	Med	Med	High
3	Med	Med	High	High
4	Med	High	High	High

TABLE 4.
CONVERSION MATRIX FOR DETERMINING RISK FROM THE CRITERIA SCORES FOR NEGATIVE OUTCOMES

Is It Risky?
Combining Magnitude and Certainty

Magnitude \ Certainty (understanding + predictability)	1	2	3	4
1	Med	Med	Low	Low
2	High	Med	Med	Low
3	High	High	Med	Med
4	High	High	High	Med

Appendix B
Evaluation Worksheets

ESA PWA

CM 01: GRAVEL AUGMENTATION

Scientific Evaluation Process (SEP) Worksheet

Table of Contents

Conservation Measure Description

The area of suitable salmonid spawning and rearing habitats in the Stanislaus River has been substantially reduced due to anthropogenic influences including dam construction, in river aggregate mining, and the conversion of floodplain habitat for agricultural uses. The annual sediment deficit was estimated to be 28,500 tons and more than 1 million cubic yards and 5 million cubic yards of aggregate material were mined from the channel and floodplain, respectively (Kondolf et. al. 2001). Suitable spawning habitat typically consists of framework grains of a size movable to females during redd construction (approximately 10% fork length), low levels of fine sediment accumulation, and gravel permeability sufficient to allow minimum intra-gravel dissolved oxygen and water velocity requirements of salmonid eggs (Kondolf 2000, Merz and Setka 2004). The proposed action is within the lower Stanislaus River between Goodwin Dam (RM 58.4) and Riverbank (RM 33).

- **Primary Outcome:**

  Restore spawning habitat for adult Chinook salmon to increase egg to emergence survival.

  - Implicit = increase amount of suitable Chinook salmon spawning habitat (area).
  - Alternate statement of outcome = increase the number and longitudinal distribution of Chinook salmon redds and decrease superimposition by 90% and female egg retention to levels less than 10% in the lower Stanislaus River from Goodwin Dam (RM 58.5) to Riverbank (RM 33). The number of redds per square meter indicates whether salmon find the gravel appropriate for spawning (0.03 redds/square meter is a standard guideline). The level of egg retention in females indicates whether there are a sufficient number of suitable sites to spawn (less than 10% retention is a standard guideline). The percentage of salmon using emplaced gravel indicates whether the action is providing habitat that is suitable (the action should aim for 10% on the Stanislaus River).

- **Secondary Outcomes:**
  - Macro-invertebrate production
  - Implicit = Increase channel habitat complexity.
  - Implicit = Increase hyporheic flow and improve intra-gravel water quality (i.e. dissolved oxygen, temperature) and permeability for egg incubation, within the gravel size distribution appropriate for redd construction.
  - Implicit = Increase life history diversity by improving spawning and egg incubation conditions (i.e. spatial and temporal).
  - Implicit = Improve riparian habitat and cottonwood recruitment by restoring fluvial geomorphic processes.
  - Implicit = Reduce predation on juvenile Chinook salmon by isolating ponded sections and/or creating diverse pool/riffle/run complexes in the river and creating alluvial braided channels.
  - Increasing the area of suitable spawning habitat should decrease the area of habitat available for predatory fish.

- **Action:** Increase and enhance Chinook salmon spawning habitat by adding at least 50,000 cubic yards of gravel and maintaining no net loss of gravel thereafter. There is only 25,493 m^2 of suitable spawning area available which may support 1,270 spawning pairs of Chinook salmon (Kondolf et. al. 2001). The suitable spawning area needs to be increased by at least 40% in order to restore the historic gravel beds between Goodwin Dam (RM 58.4) and Orange Blossom Rd. Bridge (RM 46.9) (NOTE: the CM authors noted that they wished to obtain "redd data from FishBio and estimates of redd superimposition").

- **Approach:**
    - Increase and improve Chinook salmon spawning and rearing habitat by adding cleaned spawning sized gravels to degraded areas within the 25.5 mile salmonid spawning reach in the lower Stanislaus River.
    - Approximately 50,000 Cubic Yards of cleaned spawning sized gravel and larger cobble will be harvested from the project area and inserted into the river, creating or restoring riffles, and restoring fluvial geomorphic processes.
    - Aggregate harvest will be completed in a manner that creates new floodplain areas, and in-channel placement will be completed in a manner that increases local floodplain inundation (e.g., raises the channel bed).

- **Background:**

  In the Stanislaus River, as in many Central Valley systems, a series of dams in the upper watershedhas blockedaccess to spawning habitat in the upper river, and has blocked the transport of gravel to downstream reaches. Gravel recruitment was reduced by 92% following construction of Goodwin Dam at river mile (RM) 58 in 1912. Mobilization of gravel and fines below Goodwin Dam was furtherreduced in 1981 when expansion of the New Melones Dam reduced the frequency and magnitude of flooding in the lower reaches (Kondolf et al. 2001) inhibiting the flushing of fine particles (<0.85mm) from coarser bed materials (CDWR 1994). High volumes of fine particles are detrimental to the survival of Chinook salmon and steelhead eggs (Reiser and White 1988) and have been found to reduce salmonid egg survival to emergence by as much as 95% (Meyer 2003). In 1994, the California Department of Water Resources found that 45% of the 22 riffles they surveyed between Goodwin Dam and Riverbank on the Stanislaus River were unsuitable for salmonid spawning due to high levels of fine particle accumulation (CDWR 1994). In addition to damming in the upper watershed, gold and aggregate mining have had a detrimental effect on spawning and rearing habitats. Approximately 40% of historic gravel beds were excavated from the 13.6-mile reach between Goodwin Dam and Orange Blossom Bridge between the years 1939 and 1980 for gold and aggregate mining purposes (Mesick 2003). Mining activities left instream pits and long, uniform ditches 5 to 10 feet deep and 100 to 165 feet wide in the active channel near Lover's Leap from RM 53.4 downstream to Oakdale. Gravels entering the river from tributaries below Goodwin Dam, or mobilized in high flow events become trapped in these pits rather than replenishing downstream riffles. Furthermore, these ponded sections sustain large populations of predatory fish, but provide little habitat for salmonids.

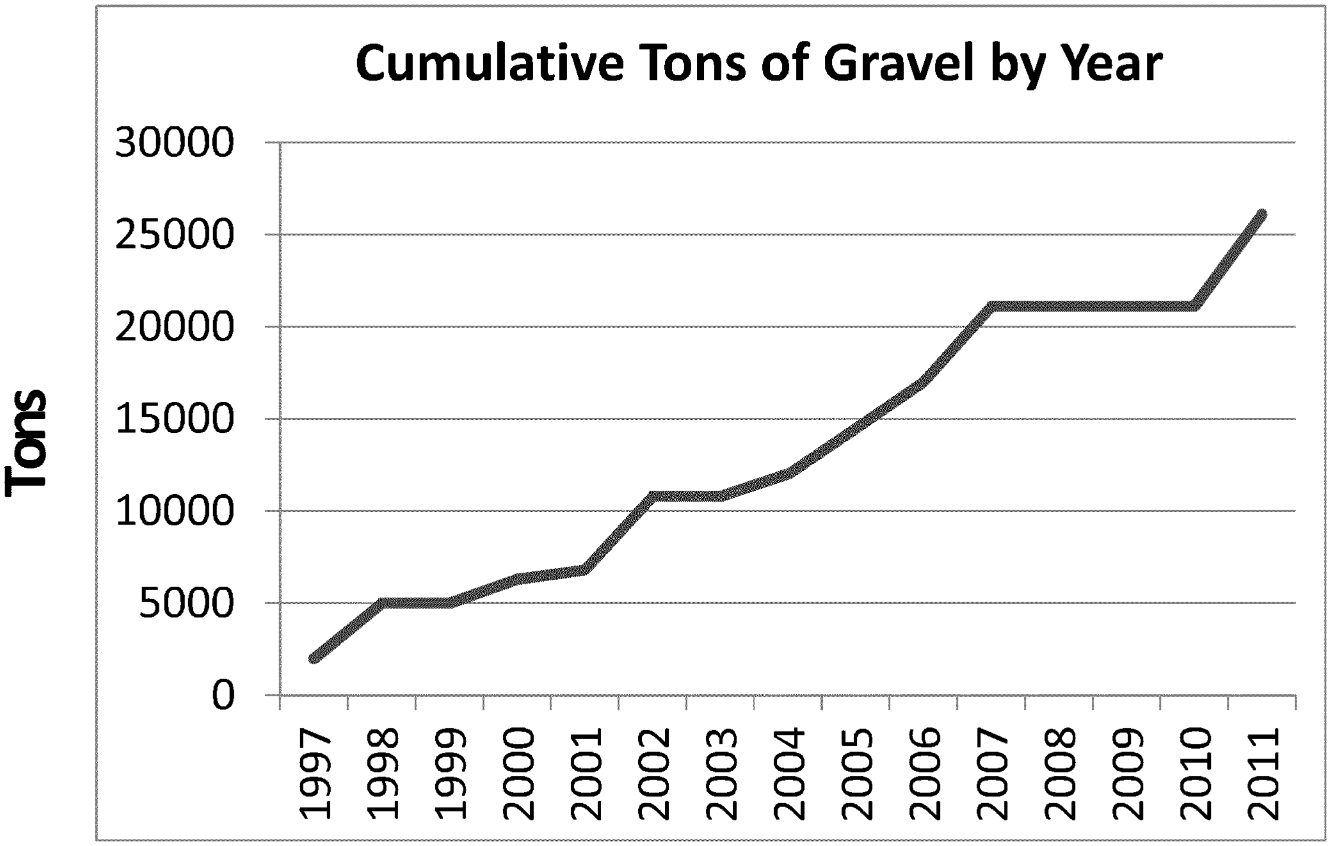

Figure 1. The cumulative tons of spawning gravel that have been added since 1997 by USBR, CDWR, CDFW, and USFWS in the Stanislaus River, CA.

FALL-RUN CHINOOK SPAWNING

Suitable Condition (Oct-Dec; GDW to RB)		Existing Condition				Restoration Opportunity		
Factor	***Range***	***Location***	***Timing***	***Range***	***Quality***	***Problem(s)***	***Potential cause***	***Impact***
Gravel Quantity	Avg. of 24 yds^2 gravel substrate per spawning pair[1]	GDW to RB	-	30,489 yds^2 of suitable spawning area in 2000[2]; can support 1,270 spawning pairs	Unsuitable	Total area of spawning gravel between GDW and RB decreased 33% from 1961 to 1972 and 40% from 1972 and 1993[3] Limited gravel recruitment Redd superimposition	40% of channel dredged from GDW to OBB[4] Gravel recruitment reduced due to blockage by dams, reduced transport flows; changes in streamside land use; riparian encroachment.	H
Gravel Quality	0.5 inches to 4.02 inches in diameter[5]	GDW to RB	-	25-40+% rifles armored[6]	Unsuitable	Armoring Redd superimposition	Infrequent bed mobilization (reduced transport flows)[7] Loss of functional floodplain habitat[8] Gravel recruitment reduced (see gravel quantity)	H
Escape Cover	Overhanding vegetation, undercut banks, submerged vegetation, submerged objects (e.g., logs and rocks), floating debris, and water depth and turbulence[9]	GDW to RB	Oct-Dec	Unknown[10]	Unknown	-	-	Unknown

1. Burner 1951
2. Kondolf and others 2001.
3. CDFG 1972. DWR 1994.
4. Appendix 2 prepared by Carl Mesick Consultants 2003.
5. Bell 1973, as cited in Reiser and Bjornn 1979.
6. CMC and others 1996 reported 25% of riffles armored (i.e., consisting of cobble or bedrock rather than gravel); however, surveys conducted by Mesick during 2002 indicate that this estimate increased to at least 40% as a result of high flows in 1997 and 1998 (Carl Mesick, personal communication, 2005).
7. McBain and Trush 2003.
8. Kondolf and others 2001; McBain and Trush 2003.
9. Giger 1973 as cited in Reiser and Bjornn 1979.
10. No surveys have been conducted to quantify escape cover.

SEP Evaluation of the Conservation Measure

Evaluation Team

Lead Author:	Andrea Fuller (SJTA)
Support Authors:	Rachel C. Johnson (USBR), Ron Yoshiyama (UC Davis on behalf of SFPUC)
Reviewer:	Josh Israel (USBR)
Workshop Participants:	This conservation measure was discussed by the entire group. Rene Henery (Trout Unlimited), Alison Weber-Stover (Bay Institute), Michael Martin (Merced River Cons. Comm), John Cain (American Rivers), Jeanette Howard (TNC), Julie Zimmerman (USFWS) and Ramon Martin (USFWS) Eric Ginney (ESA - facilitator), John Wooster (NMFS), Bruce DiGennaro (Essex Partnership - facilitator), Sean Maguire (Kennedy/Jenks - notes), and Jessica Olson (ESA - notes).

Date of Evaluation Workshop; time CM was evaluated

Conservation measure, scale, and which outcomes should apply were reviewed by Evaluation Team on the morning of April 9, 2013. Only a portion of the applicable outcomes were reviewed and scored during the Evaluation Workshop. Following the workshop, Andrea Fuller took the lead in drafting an evaluation with input from Rachel C. Johnson and Ron Yoshiyama. On May 2, 2013 the draft evaluation was reviewed by the larger evaluation team members present- Andrea Fuller, Rachel Johnson, Michael Martin, John Wooster, Julie Zimmerman, Ramon Martin, John Cain, and Ron Yoshiyama during a follow-up meeting. After this discussion Andrea revised the evaluation to reflect the latest discussion and provided an updated draft (version 2) to Ron and Rachel on May 7, and to Josh on May 8. Additional edits were made to the document to further develop Outcome P9, and to address comments provided by Ron, Rachel, and Josh, resulting in version 3 of the worksheet.

Modifications to the Conservation Measure

The following modification was made to the Action:

> "Increase and enhance Chinook salmon spawning habitat by adding ~~at least~~ 50,000 cubic yards of gravel and maintaining no net loss of gravel thereafter."

The following modification was made to the Approach:

> "Increase and improve Chinook salmon spawning and rearing habitat by adding cleaned spawning sized gravels <u>to degraded areas of the salmonid spawning reach in the lower Stanislaus River between Goodwin Dam (RM 58.4) and Orange Blossom Bridge (RM 46.9)</u> ~~within the 25.5 mile salmonid spawning reach in the lower Stanislaus River~~."

Clarifying Assumptions

- 11.5 mile reach

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- Existing riffles will be enhanced and new riffles will be created in runs similar to the approach to the Lovers Leap Project completed in 2007 (KDH 2008).
- New and enhanced riffles at Lovers Leap averaged 105 feet wide. Depth of gravel added to beds ranged from 1.3 to 5.8 feet and averaged 3.35 feet. This project area is representative of conditions in the target reach with the exception of the high gradient, bedrock canyon which extends over approximately 2.5 miles between Goodwin Dam and Knights Ferry.
- Riffle area at Lovers Leap was increased by 100,438 square feet (KDH 2008). In addition to the new area created, six riffles were enhanced using an unknown, but presumably small proportion of the material placed. Note: this is actual increase in area, not the sum of existing and enhanced.
- The 27,076 tons of gravel placed at Lovers Leap was calculated to be roughly equivalent to 20,000 CY of gravel, therefore 50,000 CY of gravel would be expected to provide approximately 2.5 times the area created at Lovers Leap, or roughly 250,000 square feet of new spawning riffle area.
- No change in riffle area was assumed to occur as a result of enhancing existing riffles.
- Gravel augmentation patches would be evenly distributed over the treatment reach.
- Gravel will be excavated near the location of riffle augmentation.
- Floodplain will be graded suitably to recruit riparian vegetation.
- Creating alluvial braided channels was assumed to include creation of sidechannels.
- Assumed that “with no net loss thereafter” implies maintenance of spawning area that has been created—thus we assume sediment supplementation through time (i.e., a sediment budget will be developed and a maintenance program implemented).
- 50,000 CY is the amount required by RPA III.2.1 of NMFS Biological Opinion (NMFS 2009) to avoid jeopardy to O. mykiss. Not linked to estimated spawning gravel area lost or amount needed to support doubling of Chinook salmon.
- During 2007-2012 the majority (avg: 70%, range: 50-83%) of spawning (FISHBIO 2013) occured in this reach where an estimated 40% historical spawning gravels have been lost (Mesick 2003).
- The spawning reach extends another 14 miles downstream to Riverbank and loss of historical spawning area in this reach has not been estimated.
- The AFRP doubling goal for the Stanislaus River is 22,000 Chinook salmon which includes harvested fish that do not return to the spawning grounds. During 1992-2010 the USFWS estimated that an average of 42% of Stanislaus River adult salmon production was harvested (USFWS 2011). It was assumed that harvest would continue at this rate and the resulting doubling goal for escapement would be 12,760 individuals or 6,380 spawning pairs at a 50:50 gender ratio.
- Existing suitable spawning habitat area is 25,493 sq. meters or 274,404 square feet (Kondolf and others 2001).
- Placement of 50,000 CY of gravel would nearly double the amount of suitable spawning area in the Stanislaus River.

- The existing area of suitable spawning habitat is estimated to support 1,270 spawning pairs. To support doubling, a five-fold increase in spawning habitat area is needed.
- Redd superimposition occurs at high levels even when spawner abundance is low such as in 1996 when fewer than 200 fish were estimated to have spawned and redd superimposition in this reach was estimated to be 24% (Mesick 2001). Redd superimposition documented through more comprehensive surveys in 2012 was estimated to be 42% in the uppermost riffles near Two Mile Bar and Goodwin Dam (FISHBIO 2013). Redd superimposition in this reach is believed to be underestimated due to the heavy spawning activity (Guignard 2005). Redd superimposition between Knights Ferry and Orange Blossom Bridge during 2012 was 16% (FISHBIO 2013).

TABLE 1
ESTIMATED EXISTING SPAWNING RIFFLE AREA, NEW RIFFLE AREA CREATED, AND NUMBER OF SPAWNING PAIRS SUPPORTED.

	Gravel Added (tons)	Gravel added (cy)	New Riffle Area (sq. Ft)	Total Riffle Area (sq. Ft.)	Number of Spawning Pairs suppOrted
Estimated in 2000				274,404[1]	1,270
After Lovers Leap	27,076	20,000	100,438[2]	374,842	1,735
Conservation Measure		50,000	251,095	625,937	2,897
Estimated for Doubling Goal		199,848	1,003,238	1,378,080	6,380

1. Kondolf and others 2001
2. KDH 2008

Scale of Action- Large

Rationale:
The scale of the action was determined to be large due to the following:

- Broad spatial extent: 11.5 mile reach where, on average, 70% of salmon spawning occurs (FISHBIO 2013).
- Significant duration and/or frequency: Increase in spawning area is permanent given the assumption of no net loss through continued maintenance.
- Major reversal compared to existing conditions: Nearly doubles the amount of suitable spawning habitat resulting in capacity to support nearly twice as many spawning adult salmon. Existing capacity estimated at 1,270 spawning pairs which is only 20% of the CVPIA doubling goal of approximately 6,380 spawning pairs. This conservation measure would increase the capacity to 40% of the goal.

While the above captures the majority opinion, it was noted by John Wooster and Josh Israel that since the conservation measure would not place an amount of spawning gravel sufficient to support doubling, a scale of medium should be considered.

Evaluation Summary

Potential Positive Ecological Outcome(s)

Outcome P1: Increased Habitat Connectivity

Clarifying Assumptions:

- There are opportunities to achieve connectivity between channel and side-channel/floodplain habitat despite landowner constraints and channel morphology. Opportunities would be limited to the reach between Knights Ferry and Orange Blossom, approximately 7 miles.

Scientific Justification:

- **Magnitude #2:** Channel and floodplain accommodate different life-stages such as spawners and eggs, but both habitats may be used for juvenile rearing. The conservation measure will increase accessibility of rearing juvenile salmon to currently perched floodplain habitats though excavation, and these areas will be adjacent to gravel augmentation sites where spawning and incubation occur allowing for increased connectivity of spawning, incubation, and rearing habitats. However, the magnitude was ranked low because it is expected to affect a limited to small fraction of downstream migrants, and there is uncertainty regarding the area of floodplain habitat that would be created and the frequency of inundation.

- **Certainty # 3:** Our understanding of how to achieve connectivity between the channel and floodplain/side-channels is high and recent projects have been successfully completed at Honolulu Bar and Lancaster Road on the Stanislaus River. However, there is uncertainty regarding the area of floodplain habitat that would be created and the frequency of inundation which requires reliance on external factors such as flow to create connectivity. There are examples of recent design success in the Stanislaus River including side-channel and floodplain restoration at Honolulu Bar.

Outcome P2: Additional Spawning Habitat

Clarifying Assumptions:

- Gravel and cobbles placed are of the appropriate sizes and shapes for spawning.
- Material is placed to provide suitable depth and velocity for spawning at typical base flows (200-400 cfs), and to maximize area upstream of the riffles' crests where the streambed gradient is positive (i.e., the tail of a pool). During 1994-1997, 73% of spawning occurred upstream of the riffles' crests and within the upper 30 ft of the riffle (Mesick 2001).
- Actions are implemented to maintain the increased spawning habitat area, not gravel volume, achieved by the CM.
- Spawning habitat area is increased via run to riffle conversion, and by improving the quality of existing riffles, presently unused or underused riffles may become usable and thus habitat is extended.

- Existing suitable spawning habitat area in 2000 was 25,493 sq. meters or 274,404 square feet, and completion of the Lovers Leap project increased the amount of suitable habitat to 374,842 square feet.
- Placement of 50,000 CY of gravel would nearly double the amount of suitable spawning area in the Stanislaus River.
- The existing area of suitable spawning habitat is estimated to support 1,735 spawning pairs. To support doubling, nearly a four-fold increase in spawning habitat area is needed.
- Redd superimposition occurs at high levels even when spawner abundance is low such as in 1996 when fewer than 200 fish were estimated to have spawned and redd superimposition was estimated to be 24% (Mesick 2001). Redd superimposition in this reach is believed to be underestimated due to the heavy spawning activity (Guignard 2005).

Scientific Justification:

- **Magnitude #3/4:** This action addresses a key limiting factor and would nearly double the present habitat extent and capacity for spawning. A doubling of current spawning habitat capacity is likely to have a major population level effect supporting a score of 4. However, it should be noted that even a doubling of current spawning area is not enough to support the number of spawning fish under the AFRP doubling goal. There are also external factors which could limit the extent to which this action would result in a significant population level effect. For example, if the river is not exclusively spawning habitat limited, but also rearing habitat limited, then an increase in number of successful spawners may not result in an increase in juvenile production or significant population level effect warranting the inclusion of a magnitude score of 3. The magnitude score of 3 was also included to reflect the minority opinion that the increased extent of habitat area created would still be short of what is needed to support doubling and may not result in a major population effect.

- **Certainty # 3:** Understanding is high that poor quality spawning and rearing habitat can be improved and extended with the addition of good quality spawning gravel to achieve suitable depth, flow, and velocity conditions for spawning (Merz and Setka 2004, Merz et. al 2004, CMC and KDH 2009). There is high certainty that the habitat extent for spawners will be increased, and that juvenile production would be increased, but whether this results in an outcome of increased abundance of returning adults is dependent upon other factors such as successful juvenile rearing, successful migration, and harvest. There is also some uncertainty in design elements that may or may not result in fish use or incubation success (Zimmerman personal communication), however, there is a weight of evidence and that supports our understanding of design elements that are successful (Kondolf 2000, Merz and Setka 2004, Merz et. al 2004) and the success of this conservation measure is dependent upon the combined results from all riffles created, not the success of a single riffle.Micro-topography of the augmented areas and adjacent areas may determine whether the newly created gravel patches are used. Chinook spawners appear to favor spots that have downwelling flows (Kondolf 2000). The degree of contouring provided by the initial placement of gravel patches may affect the extent of use by spawners, at least for a period until subsequent geomorphic flows re-shape the gravel patches. Several gravel augmentation projects have been completed in the Stanislaus River, and both new and enhanced riffles have been used by spawning Chinook salmon, most within a few months following gravel placement.

Outcome P3: Additional Rearing Habitat

Clarifying Assumptions:

- None

Scientific Justification:

- **Magnitude # 3:** Juvenile rearing habitat with suitable depths and velocities is limited in the Stanislaus River due to channel incision and historical gravel extraction. Converting run habitat to riffle habitat, and creating floodplain and side-channel habitats would increase overall juvenile rearing capacity which would be expected to result in a sustained minor population effect. In addition, Suttle et al. 2004, show that juvenile salmon use clean gravel (without fines) as interstitial refuges and rearing habitats. Opportunities to couple gravel augmentation with side-channel and floodplain creation are limited.

- **Certainty # 2:** There is low certainty that gravel placement would increase carrying capacity in a meaningful way. Associated actions of creating side-channels and large-scale floodplains are more likely to improve rearing habitat.

Outcome P6: Reduce Habitat for Predatory Fish

Clarifying Assumptions:

- Predators of Chinook salmon found in this reach are primarily Sacramento pikeminnow and striped bass. Smallmouth bass and largemouth bass are not frequently observed in this reach.

Scientific Justification:

- **Magnitude #2:** Roughly doubling riffle area would decrease habitat for Sacramento pikeminnow and striped bass through conversion of runs to riffles. However, displaced predators may still be in proximity to augmentation patches and prey upon young salmon. Minor effects to a fraction of the predator population is expected to result in minor change in productivity of Chinook salmon. Placement of clean gravel to enhance riffles also provides interstitial refuges during early lifestage rearing (Suttle et al. 2004)

- **Certainty #2:** Extent of predator habitat reduction would depend upon size of augmentation patches and proximity/topography of areas harboring predators. Understanding of how reducing habitat for Sacramento pikeminnow and striped bass would affect abundance of these species in the target reach is low as is understanding of how changes in abundance may alter juvenile salmon survival. Predator abundance, distribution, and predation rates in the target reach are unknown.

Outcome P7: Increased establishment of woody riparian vegetation providing shaded channel habitat, increased channel margin complexity, and the export of large woody debris.

Clarifying Assumptions:

- There are no levees in this reach.
- Incised channel.

Scientific Justification:

- **Magnitude #2:** Few opportunities exist indicating limited spatial scale. Minor effect on productivity and diversity of Chinook salmon expected.

- **Certainty #3:** Understanding of the potential benefits of woody riparian vegetation is high; however the outcome is highly uncertain. The extent to which establishment of woody riparian vegetation would be increased is highly dependent on the contouring of streamside areas where gravel is harvested for placement instream and whether conditions (i.e., inundation frequency and duration) in these areas are made more favorable for establishment of woody riparian vegetation.

Outcome P9: Increase Hyporheic Exchange

Clarifying Assumptions:

- Increased hyporheic flows in existing riffles that are restored will reduce water temperatures, increase DO, and improve permeability.
- Egg survival will increase due to improved hyporheic conditions.
- Much of the fine sediment in existing spawning gravel that is currently being used is improved by adults when redds are constructed (Kondolf et al., 1993, Gottesfeld et al. 2004).

Scientific Justification:

- **Magnitude #2/3:** Hyporheic exchange is not believed to be a key limiting factor on the Stanislaus River, but hyporheic conditions may be improved in existing, degraded riffles through addition of clean gravel. Improved conditions would be expected to include reduced fine sediment, reduced temperature, and improved DO. Finer sand and silt particles are washed out of the larger gravel matrix during redd construction (Kondolf et al., 1993, Gottesfeld et al. 2004), and it is unclear to what extent fine sediments could be further reduced through the placement of clean gravels. The magnitude of change in productivity is highly dependent upon the present rates of survival to emergence relative to the rates after gravel augmentation. Limited information exists to describe present rates of survival to emergence in the Stanislaus River. A study on the Stanislaus River during 2004 (CMC and KDH 2009) suggested that the percentage of fines in actual salmon redds was only slightly lower in restoration sites than in natural gravels, and that the percentage of eggs that survived to the fry stage in incubation chambers was relatively high at restored sites at Lovers Leap, but not statistically different from the nearby control site where the gravel bed was armored and bed permeability was moderate, suggesting that gains in survival to emergence may be low. Improvement of hyporheic conditions in degraded riffles may also promote use of presently unused or underutilized areas thereby also reducing redd superimposition. Improvement in hyporheic conditions by adding material to existing riffles is expected to have a lesser effect on productivity than increasing riffle area through the construction of new riffles.

- **Certainty #2:** Understanding is high that hyporheic conditions largely determine incubation success, how gravel should be placed, and that survival to emergence can be improved through riffle enhancement (Merz and Setka 2004, Merz et. al 2004). However, the magnitude of change in productivity is highly dependent upon the present rates of survival to emergence relative to the rates after gravel augmentation. Limited information exists to describe present rates of survival to emergence in the Stanislaus River. An egg chamber study conducted during 2004 (CMC and KDH 2009) found that the percentage of eggs that survived to the fry stage in incubation chambers was relatively high at restored sites at Lovers Leap, but not statistically different from the nearby control site where the gravel bed was armored and bed permeability was moderate, suggesting that gains in survival to emergence may be relatively minor. More study is needed.

Outcome P11: Contributes to conditions with water temperatures appropriate for salmonid migration, spawning, incubation, and rearing

See Outcome P9

Outcome P12: Increased production and local availability of aquatic food resources (macro invertebrates)

Clarifying Assumptions:

- Increased macroinvertebrate production within the river.

Scientific Justification:

- **Magnitude #2:** There is no information to suggest that food supply is a key limiting factor for Chinook salmon in the Stanislaus River. Creating new riffles and off-channel habitats will likely increase food production. The conversion of deeper silty habitat to coarser substrate riffles through gravel addition provides for the colonization of aquatic invertebrates important in juvenile salmon diets (Merz and Chan 2005, Suttle et al. 2004). The effects are expected to be localized. It is unclear the extent to which the increase in food production will occur in enhanced riffles that were not compromised by fine sediments for the aquatic community of macro-invertebrates. The long-term success of this action would also depend on the project site. Locations that accumulate fines, will likely revert to this state after gravel placement. There is also uncertainty in the quantity of food produced by this action. The food production may function to satisfy the new demand created by the increase number of juveniles produced by increasing the spawning and rearing carrying capacity, thus not having a net effect on the existing juveniles.

- **Certainty #3:** Understanding is high that added gravels can increase production of invertebrates found in salmon diets (Merz and Chan 2005), but how additional food production would affect the Chinook salmon population is uncertain as this does not appear to be a key limiting factor and increased food supply may only satisfy demand of increased number of juveniles produced due to increased capacity to support successful spawning an incubation.

Outcome P14: Food resources produced on the restored habitat will be exported and contribute to food availability in downstream aquatic areas. (Note: food resouces could include organic carbon, macro invertebrates and other organisms).

See Outcome P12

Outcome P16: Decreased mortality from excessive temperatures

See Outcome P9

Outcome P17: Reduced predation mortality (i.e. due to striped bass, black bass, and other non-native predatory species).

Clarifying Assumptions:

- Predators of Chinook salmon found in this reach are primarily Sacramento pikeminnow and striped bass. Smallmouth bass and largemouth bass are not frequently observed in this reach.

Scientific Justification:

- **Magnitude #2:** Roughly doubling riffle area would decrease habitat for Sacramento pikeminnow and striped bass through conversion of runs to riffles. However, displaced predators may still be in proximity to augmentation patches and prey upon young salmon. Minor effects to a fraction of the predator population is expected to result in minor change in productivity of Chinook salmon.

- **Certainty #2:** Extent of predator habitat reduction would depend upon size of augmentation patches and proximity/topography of areas harboring predators. Understanding of how reducing habitat for Sacramento pikeminnow and striped bass would affect abundance of these species in the target reach is low as is understanding of how changes in abundance may alter juvenile salmon survival. Predator abundance, distribution, and predation rates in the target reach are unknown.

Outcome P19: Reduced sublethal effects (genetic, tissue/organ damage, development, reproductive, growth, and immune) of mercury on covered fish species.

Clarifying Assumptions:

- None

Scientific Justification:

- **Magnitude #2:** Extent of current mercury content of spawning gravels is unknown.

- **Certainty #2:** Extent of current mercury content of spawning gravels is unknown.

Outcome P20: Increase juvenile Chinook salmon growth rate

Clarifying Assumptions:

- None

Scientific Justification:

- **Magnitude #2:** Sub-lethal effects of poor quality hyporheic conditions can retard growth and development (Suttle et al. 2004, Environment Agency 2009), and can influence longer term survival after emergence from the gravel into the stream channel (Environment Agency 2009). However this is expected to address productivity in a minor way because improvements to poor hyporheic conditions and food supply are low magnitude outcomes from this action (see outcomes P9 and P12). Similarly, it is unclear to what extent the increase in spawning carrying capacity will manifest in greater juvenile production and/or influence rearing conditions such that greater growth rates will also be supported.

- **Certainty #2:** The availability of food, good incubation and rearing habitat, and temperature strongly influence salmon growth. There is some uncertainty in the extent to which an increase in food supply (provided by this action) could increase the number of individuals supported rather than the growth rates (e.g., size) of the individuals. Other factors such as flow and temperature also have a large influence on growth rates and size at emigration.

Outcome P21: Increasing temporal distribution of freshwater lifestages

Clarifying Assumptions:

- This outcome includes the broadening of the temporal distributions of spawning, incubation, rearing, and outmigration.
- Extraneous factors (i.e., outside the river) do not constrain the duration of the migration window during which spawners can enter the Stanislaus River.

Scientific Justification:

- **Magnitude #2:** Maintaining variation in lifehistory traits is favorable under intra and inter environmental stochasticity and for resiliency with future climate change (Ruckelshaus et al. 2002, Beechie et al. 2006, Schindler et al. 2010). Increased amount of spawning area may allow more late-arriving spawners to find vacant areas, thereby potentially reducing redd superimposition and decreasing the chances that the earlier arriving spawners would have their redds superimposed by later spawners. Overall this would be expected to broaden the period of successful spawning and emergence. This may translate into an increase in the abundance of earlier and later emerging fry, potentially influencing outmigration success through maintaining diversity in size and timing of outmigration. However, considerably more gravel is needed to support doubling so redd superimposition may continue to be a key limiting factor and the influence of this conservation measure on the diversity of outmigration may only be affected to a minor extent.

- **Certainty #2:** Understanding is high that redd superimposition is a key limiting factor in terms of juvenile production, but understanding of how this affects lifehistory diversity on a population level is low. The nature of this outcome is dependent on several factors including:
    - The extent to which date of emergence and timing of juvenile outmigration may be affected by reduced redd superimposition.
    - How changes in emergence timing and timing of juvenile outmigration translates to an increase in adult abundance or overall population resiliency.
    - How changes in emergence timing and timing of juvenile outmigration population level effect in terms of potential shifts in spawn timing. Timing of upstream migration and spawning may be determined by genetics in which case timing may not change.

Potential Negative Ecological Outcome(s)

Outcome N5: Potential for increased mercury methylation, local bioaccumulation and impact on covered species (on floodplain and downstream)

Clarifying Assumptions:

- Assumed that gravels used for augmentation will be cleansed of any mercury that may be present in potential gravel sources.

Scientific Justification:

- **Magnitude #1**
- **Certainty #4**

Data Gaps, Key Uncertainties, New Ideas, and Suggestions for Future Planning

Data Needs:

- Comparison of redd superimposition rates in 2007-2011 when abundance was low to rates during 2012 when abundance was high.
- Hyporheic conditions in existing riffles.

- Survival to emergence in existing riffles.
- Seasonal and daily movements of free-ranging predators such as striped bass and pikeminnow need to be determined in greater detail in order to ascertain their effects on salmon juveniles in restored areas.

Key Uncertainties and Research Needs:

- The area of spawning habitat that would be created given the specified volume of material is uncertain. Quantification of the area created would improve certainty.
- The potential to create side-channel and floodplain habitat is not quantified and in the absence of this information there is great uncertainty in evaluating the potential benefits of that element of the conservation measure.
- It is not clear if and how the life-history diversity of fall-run Chinook salmon actually would be increased—i.e., in the evolutionary sense—because the genetic basis of variation in run-timing in Central Valley fall-run Chinook salmon is not well understood.

Important New Ideas or Understandings:

- Cost to implement needs to include an endowment.

Potential CM Re-configurations to Increase Worth /Decrease for Implementation

- Re-configure the CM to add the estimated amount of gravel to support the doubling objective.
- De-couple gravel augmentation from creation of floodplain/side-channel creation which can be evaluated through a separate conservation measure. This would improve the magnitude and certainty of some scores.

Suggestions for Future Planning

- The evaluation team noted that much more information is available for Chinook salmon than for steelhead which will make it more challenging to address habitat needs such as spawning gravel quantity as this process is expanded to address steelhead.

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Appendix A: Summary Tables Organized by Outcome

TABLE A1
OUTCOMES

Standardized Outcomes for Stanislaus River SEP		Scoring	
Standard Outcome Code	**Outcome (brief descriptor)**	**Magnitude**	**Certainty**
Habitat - Spatial Extent			
P1	Increased Connectivity	2	3
P2	Spawning	3/4	3
P3	Rearing	3	2
P6	Reduce Habitat for Predatory Fish	2	2
Habitat Quality			
P7	Shaded Channels /Channel Margin/LWD	2	3
P9	DO	2/3	2
P11	Water Temperature	3	2
Food			
P12	Increased Local Aquatic Primary and Secondary Production (Macro Inverts)	2	3
P14	Food Export	2	3
Mortality			
P16	Temperature	2/3	2
P17	Reduced Predation	2	2
Contaminants			
P19	Sublethal Effects	2	2
N5	Mercury Methylation	1	4
Size			
P20	Increase juvenile chinook salmon size at emigration	2	2
Life History			
P21	Increase life history diversity (or diversity of outmigration)	2	2

Standard Outcome Code	Outcome (brief descriptor)	WORTH		RISK		WORTH		RISK	
		Grade	Numeric	Grade	Numeric	Grade	Numeric	Grade	Numeric
Habitat - Spatial Extent									
P1	Increased habitat extent and connectivity	Med	2			Med	2		
P2	Spawning	High	3			High	3		
P3	Rearing	Med	2			Med	2		
P6	Reduce Habitat for Predatory Fish	Med	2			Med	2		
Habitat Quality									
P7	Shaded Channels /Channel Margin/LWD	Med	2			Med	2		
P9	DO	Med	2			Med	2		
P11	Water Temperature	Med	2			Med	2		
Food									
P12	Increased Local Aquatic Primary and Secondary Production	Med	2			Med	2		
P14	Food Export	Med	2			Med	2		
Mortality									
P16	Temperature	Med	2			Med	2		
P17	Reduced Predation	Med	2			Med	2		
Contaminents									
P19	Sublethal Effects	Med	2			Med	2		
N5	Mercury Methylation			Low	1			Low	1
Size									
P20	Increase juvenile chinook salmon size at emigration	Med	2			Med	2		
Life History									
P21	Increase life history diversity (or diversity of outmigration)	Med	2			Med	2		

CM 02: PREDATOR CONTROL

Scientific Evaluation Process (SEP) Worksheet

Table of Contents

Conservation Measure Description

Non-native species are important contributors to species declines and extinctions in aquatic ecosystems (Miller et al. 1989, Allan and Flecker 1993, Kruse et al. 2000). The Sacramento-San Joaquin Delta ecosystem historically supported fisheries, along with urban development, recreation, and agricultural production. However, recently the Delta ecosystem has changed substantially (Moyle 2002, Marchetti et al. 2006, Marchetti and Moyle 2001). Currently, non-native species comprise the majority of all flora and fauna in the Delta, with surveys documenting that 95-99% of all Delta biomass consists of non-native species (Cohen and Carlton 1998). Non-native species are also extant in Delta tributaries. For example, in the Stanislaus River, substantial numbers of non-native species have been documented, including multiple species such as striped bass (*Morone saxatilis*), largemouth bass (*Micropterus salmoides*), and smallmouth bass (*Micropterus dolomieu*) that are known predators of Chinook and other native fishes (Demko and others 1999, FISHBIO 2010).

Recent estimates of juvenile Chinook salmon outmigrant mortality exceeded 90% through the San Joaquin Delta in 2010 and 2011 (SJRGA 2013), and 63-95% in the Stanislaus River (CDFW unpublished, USFWS unpublished, FISHBIO unpublished data). Several of these studies have identified predation by non-native species as a significant source of mortality of juvenile Chinook salmon in the San Joaquin Basin (USFWS unpublished, Demko and others 1999, Hankin and others 2010, SJRGA 2011, SJRGA 2013). Reduced juvenile survival due to predation is one factor hampering efforts to increase salmon abundance. Suppression of predation would improve salmonid survival.

- **Primary Outcomes:**
  - Improved survival of juvenile Chinook salmon between Oakdale and Caswell.
  - Improved species composition favoring native species assemblages.
- **Action:**
  - Reduce predation losses of outmigrating juvenile Chinook salmon in the lower Stanislaus River between Oakdale (RM 40.1) and Caswell (RM 8.6) (Figure 1).
- **Approach:**
  - Implement a predator suppression program in the lower Stanislaus River to reduce non-native predator abundance by 5-10% annually by:
  - Operating upstream and downstream weirs to deter migration of predators into the lower Stanislaus River (Figure 1),
  - Year-round removal of striped bass (*Morone saxatilis*), largemouth bass (*Micropterus salmoides*), and smallmouth bass (*Micropterus dolomieu*) using a combination of techniques, including weirs, wire fyke traps, electrofishing, angling, gillnetting, and seining.

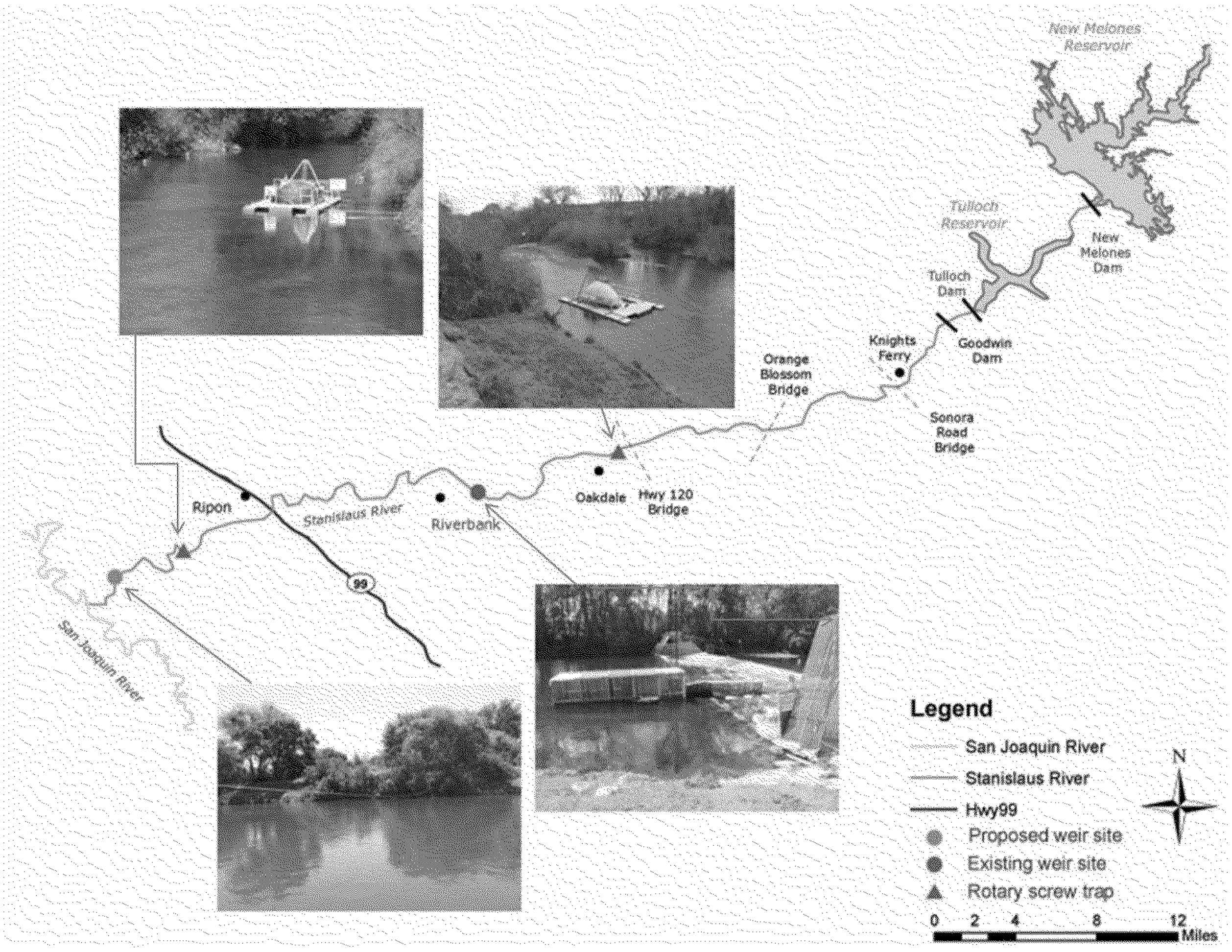

Figure 1. Lower Stanislaus River (New Melones Reservoir to the San Joaquin River confluence). Photographs illustrate the existing upstream weir, proposed downstream weir site, and existing rotary screw traps.

- **Background:**

  In the United States, 44 native fish species are threatened or endangered due to non-native fishes, and at least 27 native fish species are negatively impacted by non-native species (Wilcove and Bean 1994). Further, 70% of federal endangered species listings of fishes have cited impacts from non-native fishes (Lassuy 1995). In the western United States, the magnitude of impacts from non-native fishes rivals that of habitat destruction (Schade and Bonar 2005).

  In the Pacific Northwest, a successful predator removal program has been implemented by the Bonneville Power Administration (BPA) since 1990. After several years of testing capture methods, BPA found that for their target predator species (i.e., northern pikeminnow) and river conditions that angling was the most effective removal method and has paid anglers to remove 2.7 million large northern pikeminnow from the Columbia and Snake rivers. The Columbia River predator suppression program has cut predation on juvenile salmonids by 36% (Porter 2011).

SEP Evaluation of the Conservation Measure

Evaluation Team

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Support: Josh Israel (USBR), Rene Henery (Trout Unlimited)
Reviewer: Ron Yoshiyama (UC Davis)
Workshop Participants: Josh Israel, Renee Henery, Rachel C. Johnson (USBR), Jason Guignard (FISHBIO), and Ron Yoshiyama

Date of Evaluation Workshop; time CM was evaluated

04/09/2013

Modifications to the Conservation Measure

- **Primary Outcomes:**
  - Improved survival of juvenile Chinook salmon between Oakdale (RM 40.1) and Caswell (RM 8.6).
  - Improved species composition favoring native species assemblages.
- **Action:**
  - Reduce predation losses of outmigrating juvenile Chinook salmon in the lower Stanislaus River between Oakdale (RM 40.1) and Caswell (RM 8.6) (Figure 1).
- **Approach:**
  - Implement a predator suppression program in the lower Stanislaus River to reduce non-native predator abundance by 20%-50% annually, increase annual mortality, and decrease the biomass and average size of striped bass (*Morone saxatilis*), largemouth bass (*Micropterus salmoides*), and smallmouth bass (*Micropterus dolomieu*). Specifically, predation suppression measures should be implemented between river kilometer 40.3 and 48.3 where juvenile Chinook salmon survival is lowest (USFWS, unpublished data). Exploitation and/or mortality rates will need to be at least 25%-50% to see a decrease in abundance and a predator suppression program will need to be continued indefinitely. This is mainly due to the high fecundity and ability for these species to mature earlier and grow faster.

Clarifying Assumptions

- Striped bass do not like weirs, a deterrent.
- Predators would not be removed from mining pits above suppression zone.
- Not changing predator habitat, not evaluating that as a control method.
- We assumed fish would be removed from the entire system (killed).

- Barriers would be there year round. Action would be in place when salmonids are outmigrating.
- Suppression action could have higher success rate than 5-10%.
- Removing only 5-10% wouldn't make much of a difference.
- The extent of habitat that would become open to natives as a result of this conservation measure would be dependent upon the predator density.
- Limited to spatial effect of removing predators due to control method.
- Assume action would reduce competition for food.
- Increased production of small fish, but limited overlap between non-native fishes and juvenile salmonids.
- Predator populations may shift in size in predator control experiments.
- Largemouth and smallmouth bass tend to be sedentary don't move around a lot.
- Action happens every year, is ongoing. High exploitation may need to be continued indefinitely in order to keep predator biomass and size structure suppressed.
- Removing predators from one hotspot may allow others to come into same spot.
- Suppressing predators means greater representation of smaller and earlier salmonid outmigrants although outcome may be more dependent on water temperature and flow.
- With predators gone at certain time of years, fish that are there at that time are likely to increase size and survival.
- Rearing period could last longer with implementation of CM.

Notes taken During Evaluation Workshop

- Actions- Put in weir to suppress predators upstream (deterred but not blocked off).
- Actions deter striped bass from coming in. Increased survival due to predator control.
- Striped bass do not like the weir, a deterrent.
- Would have to do control between weir and dam to control the rest
- Between river mile 40 and 36 would be the control
- Predators would not be removed from mining pits above suppression zone.
- Section of this reach has high mortality
- Oakdale has large mine pits.
- Cut off source, adjacent to rearing areas
- This is different from SJ, smaller scale of mine pits
- Not changing predator habitat, not evaluating that as a control method
- May be difficult to reduce abundance of 5-10%
- 4 mile stretch b/t screw trap
- Spawning of Chinook below the weir was observed.
- Temps were suitable below the weir
- Potential new negative would be barrier to outmigration
- Stripers are in stream year-round.

Scale of Action-Medium

Rationale:
The scale of this action is Medium because the action, by definition, would protect against or decrease predation exposure throughout a large area between the upstream and downstream weirs (48 km). The expected outcome (5-10% reduction in predator abundance) would have a sustained minor population effect since survival of outmigrating juvenile Chinook salmon through the lower Stanislaus River was estimated at $\hat{S} = 0.07$ (*SE*=0.03) (USFWS, unpublished data). Previous published studies in the Pacific Northwest and Southeast U.S. on predator removals have demonstrated (see citations below) that a larger 20-50% decrease in the abundance of non-native predator fish in the lower Stanislaus River may be necessary to induce a moderate change in the survival of juvenile Chinook salmon through this reach compared to existing conditions.

Evaluation Summary

Outcome P1: Increased Habitat Extent & Connectivity

Clarifying Assumptions:

- Suppression action could have higher success rate than 5-10% reduced abundance.

Scientific Justification:

- **Magnitude #2:** The magnitude of this outcome is Low because the sustained effect is limited to a small fraction of the population and is limited both spatially and temporally. The action would deter migratory species such as striped bass to move upstream but non-native predatory fish densities would remain unchanged throughout the lower migratory corridor (i.e. San Joaquin River and Delta). Additionally, non-native predators would be able to adapt to a predator suppression program due to their rapid growth rates, earlier maturation, and higher fecundity (Bonvechio et. al. 2011). The habitat in the lower Stanislaus River has a greater percentage of deep pools and is very homogenous. The current poor habitat quality would limit the benefits of predator suppression to juvenile Chinook salmon and would not allow them to expand their habitat extent any more than what they are currently using. This CM contributes to increasing abundance of salmonids exiting the Stanislaus but would not increase the productivity, spatial distribution, or life-history diversity.

- **Certainty #2:** The certainty of this outcome is Low since it is dependent on other highly variable ecosystem processes such as suitable temperatures, instream flows, basin hydrology, predator immigration and/or emigration, and the reproductive success of predator fish species. Additionally, our understanding is medium that the nature of the outcome will occur since other predator control studies have shown that predator abundance needs to be reduced by 50% and sustained at low predator densities in order to be able to observe positive effects (Porter 2011, Bonvechio et. al. 2011).

Outcome P3: Additional Rearing Habitat

Clarifying Assumptions:

- None

Scientific Justification:

- **Magnitude #2:** The magnitude of this outcome is Low because the sustained effect is limited to a small fraction of the predator population and is limited both spatially and temporally. Non-native predators may be able to adapt to a predator suppression program due to their rapid growth rates, earlier maturation, and higher fecundity (Bonvechio et. al. 2011). The habitat in the lower Stanislaus River has a greater percentage of deep pools and is very homogenous. A predator suppression program will not increase the amount of rearing habitat for juvenile Chinook salmon since habitat availability is mainly a function of flow (USBR 2012). The poor habitat quality would benefit juvenile Chinook salmon in a minor way and would not expand their habitat extent any more than what they are currently using (USBR 2012).

- **Certainty #2:** The certainty of this outcome is Low. Our understanding for the nature of this outcome being achieved is medium. Control measures would need to reduce predator abundance by 50% to create and sustain low predator densities in order to be able to observe positive effects (Porter 2011, Bonvechio et. al. 2011). Additionally, the nature of the outcome is dependent on other highly variable ecosystem processes such as suitable temperatures, instream flows, basin hydrology, predator immigration and/or emigration, and the reproductive success of predator fish species.

Outcome P12: Increased production and local availability of aquatic food resources (macro invertebrates)

Clarifying Assumptions:

- This CM does nothing to increase production of aquatic food resources since it does not manipulate macroinvertebrate habitat, water temperatures, or flows.

Scientific Justification:

- **Magnitude #2:** The magnitude of this outcome is Low because the sustained effect is limited to a small fraction of the population of predators that are competing for food, and the reduction of these fishes is limited spatially (only 5-10% of all predators will not represent the entire reach of river). This CM does nothing to increase production of aquatic food resources since it does not manipulate macroinvertebrate habitat, water temperatures, or flows. Predator control measures would need to reduce predator abundance by 50% and sustain low predator densities in order to be able to observe positive effects on native fish abundance (Porter 2011, Bonvechio et. al. 2011). Food habits and predation studies show that the majority of fish stomachs collected from largemouth bass (*Micropterus salmoides*) and smallmouth bass (*Micropterus dolomieu*) contained insects and macroinvertebrates (Porter 2011, Stillwater Sciences and McBain & Trush 2006, TID/MID 2013). If predator densities and abundance are reduced then interspecific competition for food resources may decrease but only if food resources are limited.

- **Certainty #3:** The certainty of this outcome is Medium since it is dependent on other highly variable ecosystem processes such as habitat condition, instream flows, basin hydrology, predator immigration and emigration, and the reproductive success of predator fish species. Food habits and predation studies show that the majority of fish stomachs collected from largemouth bass (*Micropterus salmoides*) and smallmouth bass (*Micropterus dolomieu*) contained insects and macroinvertebrates (Porter 2011, Stillwater Sciences and McBain & Trush 2006, TID/MID 2013). If predator densities and abundance are reduced then interspecific competition for food resources may decrease. There is uncertainty regarding whether or not there are competitive effects on food resources for juvenile salmonids (Bonar et. al. 2005).

  Sustained exploitation/mortality on predator populations should decrease the proportion of large fish and increase the proportion of small fish (Zimmerman et al. 1995; Bonvechio et. al. 2011), thus predator biomass and total consumption likely remains unchanged. The ecosystem processes influencing largemouth bass, smallmouth bass, and striped bass recruitment may have a larger effect than predator suppression program. Fecundity estimates for age 1 and age 2 largemouth bass range from 6,000 to 51,000 eggs per female and 8,500 to 79,500 per female (Timmons et. al. 1981). Smallmouth bass females lay approximately 2,000 eggs at each spawning, and a female can produce 2,000 to 21,000 eggs (Moyle 2002). Fecundity of striped bass is highly correlated with weight, length, and age. Age 4 striped bass females in the San Francisco Estuary produce an average of 243,000 eggs while older females may average 1.4 million eggs (Moyle 2002).

Outcome P17: Reduced predation mortality (i.e. due to striped bass, black bass, and other non-native predatory species).

Clarifying Assumptions:

- There are less fish getting eaten by predators

Scientific Justification:

- **Magnitude #2:** The magnitude of this outcome is Low because the sustained effect is limited to a small fraction of the predator population and is limited spatially. The action would deter migratory species such as striped bass to move upstream but non-native predatory fish densities would remain unchanged throughout the lower migratory corridor (i.e. San Joaquin River and Delta). Additionally, non-native predators would be able to adapt to a predator suppression program due to their rapid growth rates, earlier maturation, and higher fecundity.

- **Certainty #2:** The certainty of this outcome is Low since it is dependent on other highly variable ecosystem processes such as continued habitat degradation, instream flows, basin hydrology, immigration, emigration, and the reproductive success of predator fish species. Reductions in non-native predator population may improve out-migrating salmonid survival if an equal compensatory response by the remaining predators does not minimize the benefits (Beamesderfer et al. 1996; Friesen and Ward 1999). An increase in the abundance, population size structure, condition factor, or decreased consumption and predation indices might indicate such a response (Knutsen and Ward 1999). Sustained exploitation/mortality should decrease the proportion of large fish and increase the proportion of small fish (Zimmerman et al. 1995; Bonvechio et. al. 2011) but the literature shows limited and sometimes inconclusive results from such an action (Porter 2011, Bonvechio et. al. 2011, Kuzmenko et. al. 2010). Intra-specific competition for home range and forage resources might be harmful to fish populations (Crowder 1990) and control their numbers naturally. If localized increases in non-native predator consumption in the predator suppression area occur, a localized reduction of intra-specific competition could also occur, possibly as a compensatory response by remaining predators. Additionally, inter-specific competition and displacement among predators may occur where a predator's niche (e.g., of smallmouth or largemouth bass) may be reoccupied by another species (i.e. Sacramento pikeminnow) or if the habitat is modified that may increase the abundance of another predator species (McBain & Trush and Stillwater Sciences 2006).

Outcome P18: Increased survival of out-migrating juveniles by providing migration route with lower predation

Clarifying Assumptions:

- The action would deter migratory species such as striped bass to move upstream but these fish and other non-native predatory fish densities would remain unchanged throughout the lower migratory corridor (i.e. San Joaquin River and Delta).

Scientific Justification:

- **Magnitude #2:** The magnitude of this outcome is Low because the sustained effect is limited to a small fraction of the population and is limited both spatially and temporally. The action would deter migratory species such as striped bass to move upstream but these fish and other non-native predatory fish densities would remain unchanged throughout the lower migratory corridor (i.e. San Joaquin River and Delta). Survival of outmigrating juvenile Chinook salmon through the lower Stanislaus River was estimated at $\hat{S}$= 0.07 (*SE*=0.03) (USFWS, unpublished data) and this CM would address an important limiting factor. However, predator control measures would need to reduce abundance by 50% and sustain low predator densities in order to be able to observe positive effects on fish survival (Porter 2011, Bonvechio et. al. 2011) and increase survival of outmigrating juveniles, so survival benefits are likely to be very limited at the level of effort described for this CM (i.e. 5-10% predator abundance reduction).

- **Certainty #2:** The certainty of this outcome is Low since it is dependent on other highly variable ecosystem processes such as continued habitat degradation, instream flows, basin hydrology, immigration, emigration, and the reproductive success of predator fish species. Reductions in non-native predator population may improve out-migrating salmonid survival if an equal compensatory response by the remaining predators does not minimize the benefits (Beamesderfer et al.

1996; Friesen and Ward 1999). An increase in the abundance, population size structure, condition factor, or reduced consumption and predation indices might indicate such a response (Knutsen and Ward 1999). Sustained exploitation/mortality should decrease the proportion of large fish and increase the proportion of small fish (Knutsen and Ward 1999; Bonvechio et. al. 2011) but the literature shows limited and sometimes inconclusive results from such an action (Porter 2011, Bonvechio et. al. 2011, Kuzmenko et. al. 2010). Intra-specific competition for home range and forage resources might be harmful to fish populations (Crowder 1990) and control their numbers naturally. If localized increases in non-native predator consumption in the predator suppression area occur, a localized reduction of intra-specific competition could also occur, possibly as a compensatory response by remaining predators. Additionally, inter-specific competition and displacement among predators may occur where a niche may be reoccupied by another species (i.e. Sacramento pikeminnow) or if the habitat is modified that may increase the abundance of another predator species (McBain & Trush and Stillwater Sciences 2006).

Outcome P21: Increase life history diversity (or diversity of outmigration)

Clarifying Assumptions:

Scientific Justification:

- **Magnitude #2:** The magnitude of this outcome is Low because the sustained effect is limited to a small fraction of the population and is limited both spatially and temporally. The action would deter migratory species such as striped bass to move upstream but non-native predatory fish densities would remain unchanged throughout the lower migratory corridor (i.e. San Joaquin River and Delta). Additionally, non-native predators would be able to adapt to a predator suppression program due to their rapid growth rates, earlier maturation, and higher fecundity (Bonvechio et. al. 2011). Survival of outmigrating juvenile Chinook salmon through the lower Stanislaus River was estimated at $\hat{S} = 0.07$ (SE=0.03) (USFWS, unpublished data). Predator control measures would need to reduce abundance by 50% and sustain low predator densities in order to be able to observe positive effects on fish survival (Porter 2011, Bonvechio et. al. 2011) and increase survival of outmigrating salmonid juveniles. This may increase the number of parr and smolt survival through the control areas although fry predation may increase due to an increase in the proportion of small predator fish (Knutsen and Ward 1999; Bonvechio et. al. 2011).

- **Certainty # 2:** The certainty of this outcome is Low since it is dependent on other highly variable ecosystem processes such as continued habitat degradation, instream flows, basin hydrology, immigration, emigration, and the reproductive success of predator fish species. Reductions in non-native predator population may improve out-migrating salmonid survival if an equal compensatory response by the remaining predators does not minimize the benefits (Beamesderfer et al. 1996; Friesen and Ward 1999). Sustained exploitation/mortality should decrease the proportion of large fish and increase the proportion of small fish (Knutsen and Ward 1999; Bonvechio et. al. 2011) but this may have a counterproductive effect where higher proportions of smaller predator fish may consume more fry, therefore, reducing life history diversity. Additionally, inter-specific competition and displacement among predators may occur where a niche may be reoccupied by another species (i.e. Sacramento pikeminnow).

Potential Negative Ecological Outcome(s)

Outcome N6: Delayed passage and increased poaching

Clarifying Assumptions:

- Effects are limited to two weirs
- Fishing pressure: would occur during 6 month period, within 34 mile reach
- Suppression is not happening in the fall when adults are returning to spawn
- Relates to fishing regulations.

Scientific Justification:

- **Magnitude #2:** The CM is expected to have a Low magnitude negative outcome of delaying upmigrating Chinook salmon or causing increased poaching. The magnitude will not impact productivity, spatial distribution, or diversity, but may influence adult abundance. The locality of the impact, adjacent to weirs, can be managed through additional law enforcement as necessary and is of very limited spatial habitat effect.

- **Certainty #3:** The certainty of this outcome is Medium. There is considerable observational data on the Stanislaus River on delayed migration of adult Chinook salmon. Our understanding is medium since these are not published studies within the system. Delay is not influenced by variabilty in ecosystem dynamics, only the presence of the structure.

    - Data Gaps, Key Uncertainties, New Ideas, and Suggestions for Future Planning

Data Needs:

Predator abundance estimates (Mark and Recapture population estimates) and predation rates of largemouth bass (*Micropterus salmoides*), smallmouth bass (*Micropterus dolomieu*), Sacramento pikeminnow (*Ptychocheilus grandis*), and striped bass (*Morone saxatilis*) in the Stanislaus River. Age and growth information and mortality (i.e. natural and fishing) estimates of resident largemouth bass, smallmouth bass, and Sacramento pikeminnow.

Key Uncertainties and Research Needs:

- Unsure of what the competitive effect on food supply is for young salmonids.
- Not sure what 5-10% would result in b/c don't know what the predator population currently is.
- Predation at outmigration is well documented, less clear how much predators will be reduced because it is only 5-10%.

- Need predator suppression studies. Limited efficacy with high removal rates?
- We are not sure what % of predator reduction results in reduced predation mortality because it depends on size distribution of predators removed and because it's dependent on variable conservation measures and conditions.
- Need age cohort of predators, then will know if you will have impact from 5-10% removal.

Important New Ideas or Understandings:

Studies need to be implemented to assess abundance, age, and growth of largemouth bass (*Micropterus salmoides*), smallmouth bass (*Micropterus dolomieu*), Sacramento pikeminnow (*Ptychocheilus grandis*), and striped bass (*Morone saxatilis*) in the Stanislaus River. Hydrologic variability between years and seasons may influence predator abundance and stream fish assemblage. Numbers of nonnative fish may be better controlled through restoration of natural flow regimes and other restorations measures (i.e. habitat restoration) more effectively (Marchetti and Moyle 2001).

Potential CM Re-configurations to Increase Worth /Decrease for Implementation

Implement a predator suppression program in the lower Stanislaus River to reduce non-native predator abundance by 20%-50% annually, increase annual mortality, and decrease the biomass and average size of striped bass (*Morone saxatilis*), largemouth bass (*Micropterus salmoides*), and smallmouth bass (*Micropterus dolomieu*). Specifically, predation suppression measures should be implemented between river kilometer 40.3 and 48.3 where juvenile Chinook salmon survival is lowest (USFWS, unpublished data). Exploitation and/or mortality rates will need to be at least 25%-50% to see a decrease in abundance and a predator suppression program will need to be continued indefinitely. This is mainly due to the high fecundity and ability for these species to mature earlier and grow faster.

The ecosystem processes influencing largemouth bass, smallmouth bass, and striped bass recruitment may have a larger effect than a predator suppression program. Fecundity estimates for age 1 and age 2 largemouth bass range from 6,000 to 51,000 eggs per female and 8,500 to 79,500 per female (Timmons et. al. 1981). Smallmouth bass females lay approximately 2,000 eggs at each spawning, and a female can produce 2,000 to 21,000 eggs (Moyle 2002). Fecundity of striped bass is highly correlated with weight, length, and age. Age 4 striped bass females in the San Francisco Estuary produce an average of 243,000 eggs while older females may average 1.4 million eggs (Moyle 2002). Measures to reduce predation efficiency should also be considered such as habitat restoration to restore ponded sections of the river. Numbers of nonnative fish may be better controlled through restoration of natural flow regimes and other restorations measures (i.e. habitat restoration) more effectively (Marchetti and Moyle 2001).

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Appendix A: Summary Tables Organized by Outcome

TABLE A1
OUTCOMES

Standardized Outcomes for Stanislaus River SEP		SCORING	
Standard Outcome Code	**Outcome (brief descriptor)**	**Magnitude**	**Certainty**
Habitat - Spatial Extent			
P1	Connectivity of habitat	2	2
P3	Rearing	2	2
Food			
P12	Benthic Macro Inverts	2	3
Mortality			
P17	Reduced Predation	2	2
P18	Route for Out-Migration	2	2
N6	Delayed passage and increased poaching	2	3
Life History			
P21	Increase life history diversity (or diversity of outmigration)	2	2f

Standard Outcome Code	Outcome (brief descriptor)	WORTH Grade	WORTH Numeric	RISK Grade	RISK Numeric
Habitat - Spatial Extent					
P1	Connectivity of habitat	Med	2		
P3	Rearing	Med	2		
Food					
P12	Increased Local Aquatic Primary and Secondary Production	Med	2		
Mortality					
P17	Reduced Predation	Med	2		
P18	Route for Out-Migration	Med	2		
N6	Delayed Passage and increased poaching			Med	2
Life History					
P21	Increase life history diversity (or diversity of outmigration)	Med	2		

CM 03: COLD WATER REFUGIA

Scientific Evaluation Process (SEP) Worksheet

Table of Contents

Conservation Measure Description

Providing suitable water temperatures for outmigrating juvenile Chinook salmon (smolt and fry) in the lower Stanislaus and San Joaquin Rivers is necessary to improve survival. Increasing cold water releases from upstream reservoirs could require large amounts of water and may not be sufficient to create suitable water temperatures (maximum or daily average) in the lower Stanislaus and San Joaquin Rivers in late April, May, and June, particularly during heat events. Juvenile salmon may not require that temperatures are suitable throughout the entire reach during every hour of the day. Juvenile salmon are more likely to migrate at night when temperatures are cooler and can travel several miles in a twelve hour period.They will, however, require suitable temperature conditions within areas such that they can hold-over during the day when reach-averaged maximum water temperatures reach a daily peak.

This measure proposes strategically releasing pumped groundwater into the lower river reaches, along with improvements in cover habitat, to create artificial cold water refugia and cover for juveniles to hold-over during maximum daily temperature peaks. Although artificial, this measure would replicate cold water upwelling from hyporheic flow and artesian discharge that presumably moderated temperature conditions in these lower-river areas before Euro-American settlement and alterations to the river systems. This measure will not solve all temperature problems during all periods, but it could increase the frequency of suitable temperature windows for successful migration to the Delta. During heat events, fish may choose to hold in refugia for several days, but will be able to resume migration once the heat event subsides for a few days.

- **Primary Outcome:** Provide suitable water temperature refugia in select locations along the outmigration corridor for juvenile salmonids.
    - Implicit = Decrease mortality from excessive temperatures.
    - Alternate statement of outcome = Improve survival during outmigration period.
- **Secondary Outcomes:**
    - Implicit = Improve fitness of outmigrating salmon by reducing temperature-related stress.
    - Implicit = Increase length of outmigration period and thereby reduce the probability that most juveniles will enter the Delta or Ocean at the same time when conditions may be adverse to survival.
    - Implicit = Increase growth before outmigration to the Delta by allowing fish to rear longer in the lower river where food sources may be more abundant. [*Evaluators suggest removing this implicit outcome because it is more of a bandaid for high temperature events.*]
    - Implicit = Increase life history diversity (or diversity of outmigration) by allowing fish to successfully migrate during a longer period of time.
    - Implicit = Increase survival by allowing fish to hold until optimal outmigration conditions exist (i.e., pulse flow or cool period).
- **Action:**
    - Create cold water refugia every five miles between Ripon and Mossdale.
- **Approach:**
    - Pump and pipe cool groundwater (60 degrees F or 15.6°C) from the shallow aquifer and discharge into refugia zones designed with appropriate cover (large woody debris) to reduce mixing and limit predation.
- **Background:**
    - Excessive average and daily maximum water temperatures are common in the Lower Stanislaus and San Joaquin River during the spring, particularly during heat waves. Excessive temperatures may increase mortality, reduce fitness, and prevent successful migration (Myrick and Cech 2001).
    - In the Okanogan Basin in WA, alternatives were evaluated including pumping groundwater into the river to create cold water refugia. The evaluation took into

consideration many factors: feasibility and engineering uncertainties (hydrogeologic conditions, complexity of water conveyance infrastructure, aeration facilities, etc.), land ownership, permitting, water rights, cost (building, operations, maintenance), negative impacts (orchard loss, water right impairment). Main criteria for evaluating the alterantives included being near deeper, slack water pools in the mainstem for juvenile fish and included channel construction (Aspect Consulting 2010). CM reviewers are not aware of follow up review of implementation, nor progress.

SEP Evaluation of the Conservation Measure

Evaluation Team

Lead Author:	Alison Weber-Stover (The Bay Institute)
Support Authors:	Michael Martin (Merced River Cons. Comm) and Jeanette Howard (TNC)
Reviewer:	Not peer reviewed.
Workshop Participants:	Julie Zimmerman (USFWS) and John Wooster (NMFS)

Date of Evaluation Workshop; time CM was evaluated

4/9/2013; 2:00 PM

Modifications to the Conservation Measure

We made no modifications to the conservation measure but we made several suggestions for improvements in the last section below.

Clarifying Assumptions

- It is feasible to pump an adequate quantity of groundwater into the river and pools can be created.
- Assume groundwater has adequate quantity, quality (DO, pH).
- Water temperature would be around 65-70 normally during warm periods. Would not get to smoltification. Measure would just decrease mortality.
- Small scale refugia and localized woody debris pile.
- This CM could mimic thermal refugia
- Flows at Vernalis are approximately 2,000 cfs in critically dry years

Scale of Action – Small

Rationale*:*
1x 5 miles, short duration benefit, small change to ecosystem (note: the small scale ranking limited the maximum magnitude score to 2).

Evaluation Summary

Potential Positive Ecological Outcome(s)

Outcome P1-A and 1-B: Increased habitat extent and connectivity

Scientific Justification:

- **Magnitude #2:** It may increase juvenile habitat and connectivity (up- and down-stream), by providing temporary thermal refugia, but factors (see notes) may trump (or override) those benefits [migration timing, groundwater quality (temp, DO, toxics),distances between "refugia", groundwater availability and impact on groundwater resources, extent of refugia relative to flow, and feasibility of building "refugia"].

- **Certainty #1:** There is no literature regarding feasibility of this CM proposal. There are little or no data on source water quality, quantity, migration rates and juvenile fall-run condition. Research needed to determine feasibility and practicality. Uncertainty at highest level because of lack of feasibility study and background data.

Outcome P3: Additional rearing habitat

Scientific Justification:

- **Magnitude #1:** Coldwater "refugia", as identified in this CM, are temporary "resting" areas to avoid infrequent deleterious temperature conditions along fall-run Chinook juvenile migration routes in the lower Stanislaus and lower San Joaquin Rivers. The CM identifies this as an "alternative" to storage reservoir cold-water releases, but does not quantitatively identify timing, quantities of water, nor connects salmon juvenile behavior, temperature/flow profiles, and the benefits of cold-water refugia. There is a mention of coupling the cold water releases with "improvements in cover habitat", but this is also poorly defined. Therefore, there was no indication that additional rearing habitat would be provided for juveniles, rather an improvement to existing habitat.

  Literature indicates benefits from cold water refugia for juvenile salmonids (Nielsen and Lisle1994). However, our understanding of the Stanislaus and lower San Joaquin rivers indicate benefits may be limited. If thermal refugia could be provided on the Stanislaus to Mossdale, the extent to which it would provide any population level effects are limited by the low likelihood of juveniles surviving once they left the Stanislaus River (lower San Joaquin and through Delta).

- **Certainty #1:** *Rationale*: There is no literature regarding feasibility of this CM proposal. There are little or no data on groundwater source water quality, quantity, migration rates and juvenile fall-run condition. Research needed to determine feasibility and practicality. Uncertainty is at highest level because of lack of feasibility study and background data.

Outcome P9: Reduced periodic low dissolved oxygen events

Clarifying Assumptions:

- Treatment may be required to improve low DO (Mathany et al., 2013).

Scientific Justification:

- **Magnitude #2:** The CM presumes that groundwater would have high DO, and provide a DO refuge for migrating juvenile salmon. Improved DO would be expected to benefit limited number of migrating juveniles because of interactions between temperature, DO and other stressors (Myrick and Cech 2001).

- **Certainty #1:** There is no literature regarding feasibility of this CM proposal. There are little or no data on groundwater source water quality, quantity, migration rates and juvenile fall-run condition. Research needed to determine feasibility and practicality. Uncertainty is at highest level because of lack of feasibility study and background data.

  Mathany et al. (2013) indicates most groundwater quality along the San Joaquin River is very poor and unsuitable for aquatic life; further treatment may be required to improve low DO.

Outcome P11: Contributes to conditions with water temperatures appropriate for fall-run Chinook salmon juvenile migration.-

Clarifying Assumptions:

- This CM was for enhancing juvenile migration conditions, with minimal rearing (ie, provides refugia for downstream migrating juveniles). It was not for adult migration, spawning, and incubation. Appropriate temperature (DO and toxin-free) is necessary to provide a positive outcome.

Scientific Justification:

- **Magnitude #2:** The goal of this measure is to improve water temperatures for juvenile migration. The CM was given a magnitude of 2, because the CM would only be implemented in small areas of the reach and is therefore expected to benefit a small fraction of the population.

- **Certainty #1:** There is no literature regarding feasibility of this CM proposal. There are little or no data on groundwater source water quality, quantity, migration rates and juvenile fall-run condition. Research is needed to determine feasibility and practicality of this CM. Since this has not been attempted or studied, it is unclear (uncertain) whether the CM could be implemented from a feasibility standpoint (i.e., engineering, environmental and cost considerations). Uncertainty is at the highest level because of lack of feasibility study and background data.

Outcome P16: Decrease mortality from excessive temperatures

Clarifying Assumptions:

- If temperatures exceed lethal and sublethal stress values, mortalities of juvenile salmon are expected to increase. The timing of juvenile migration is important for incurring or avoiding increased juvenile mortality. Current research on the Stanislaus River suggests that the largest group of juvenile emigrants were parr sized (*Miller et al. 2010)*. Recovery efforts need to examine how to improve rearing conditions to get larger fish, earlier, and expedite their migration out of "harms way."

Scientific Justification:

- **Magnitude #2:** Presuming that juvenile fish that leave the Stanislaus River later in the migration cycle have higher mortality rates with exposure to higher (potentially lethal) temperatures, this CM may provide some mitigation, by allowing short-term avoidance of lethal temperatures. SJRGA (2011) and Lindley et al. (2009) suggested that 3 patterns of outmigration: 1) fry migrants (most abundant) migrate from tributaries soon after emergence (Jan-Feb) to the Delta; 2) smolt migrants remain near spawning areas and migrate quickly through the lower tributaries and Delta (up to 7 days), during March and April, and 3) a small number of yearling migrants migrate during fall or winter. Based on this, mortality due to temperature is more likely for the smolt migrants during intermittent thermal exceedance periods in March and April in the lower Stanislaus and San Joaquin Rivers. This indicates smaller time requirements for refugia may be possible.

- **Certainty #1:** There is no literature regarding feasibility of this CM proposal. There are little or no data on groundwater source water quality, quantity, migration rates and juvenile fall-run condition. Research is needed to determine feasibility and practicality. Uncertainty is at highest level because of lack of feasibility study and background data.

Outcome P21: Increase life history diversity (or diversity of outmigration)

Clarifying Assumptions:

- Increase the life history diversity by affecting Chinook salmon smolt migrants during April-May.

Scientific Justification:

- **Magnitude #2:** Timing of Chinook salmon smolt migration coincides with increased temperatures of the lower Stanislaus, San Joaquin Rivers, and the Delta (SJRGA 2011 Figure 4). Compliance with US EPA Temperature Criteria (US EPA 2003) increases the success and numbers of Chinook salmon smolts. The improved success of smolts versus all outmigrant juvenile stages (i.e. fry, smolts, and yearlings) increases life history diversity of fall-run Chinook salmon in the Stanislaus River population.

- **Certainty #1:** Appropriate temperature (and suitable DO and toxin-free conditions) is necessary to provide a positive outcome. Since this has not been attempted nor studied, it is unclear (uncertain) whether the CM could be implemented because from a feasibility standpoint (i.e., engineering, environmental and cost considerations). There are no literature regarding the feasibility of this CM proposal. Uncertainty is at the highest level because of lack of feasibility study and background data.

Potential Negative Ecological Outcome(s)

Outcome N3: Restoration sites create a population sink for covered fish species (Provides rearing habitat for predators (?) that becomes a one-way trip to entrainment or predation?)

Scientific Justification:

- **Magnitude #2:** By providing woody debris habitat and cold water, these sites may attract migrating smolts and larger predators. Presence of predators may increase predation rates (relative to widely dispersed migrating smolts), similar to increasing densities of juveniles with screw traps. Increased predation is generally thought to be of negative ecological value to Chinook salmon.

- **Certainty #2:**

- **Rationale***:* This has not been done before (no research to indicate its feasibility). Not sure that the lower Stanislaus reaches that are being considered are amenable to habitat structural changes (large woody debris, floodplain habitat, riparian habitat). What types of habitat engineering is needed? Environmental concerns? Costs? All of these unknowns reduce the certainty of this CM.

Data Gaps, Key Uncertainties, New Ideas, and Suggestions for Future Planning

Data Needs:

Feasibility of: location, groundwater availability, groundwater quality,

Key Uncertainties and Research Needs:

- Need to understand groundwater temperature reduction benefits as compared to ambient river water temperature.
- Need to understand time period of salmonid migration – very little understanding as to whether this would work.
- Need to understand groundwater quality implications.
- Need to understand whether 5 mile gaps between cold water pools would be adequate

- No known scientific knowledge of this solution, although there is some literature on thermal refugia.
- Connection to measureable effect on salmon population is lacking. While expanding life history flexibility is desirable, it is unclear if conditions in the system at present would allow for survival of fish once they reached the lower SJR. Sturrock et al. 2013 are investigating the juvenile fish from the Stanislaus and finding that fish leaving later in the season are not recruiting to adulthood. In attempting to move toward doubling goals, it is unclear if this CM would have any measurable affect on the population (e.g. keeping more juveniles alive, only to die in the Delta).

Important New Ideas or Understandings:

- Novel idea to attempt to re-create hyporheic flows and artesian discharges that presumably moderated temperature conditions in these lower-river areas before Euro-American settlement and alterations to the river systems.

Potential CM Re-configurations to Increase Worth /Decrease for Implementation

Suggested improvements for the conservation measure:

Current Understanding of Salmon Life History and Survival in the Stanislaus River May Indicate Limited Effects from this Conservation Measure

- The CM description does not adequately explain general fall-run juvenile migration. Current research on Stanislaus suggests that the highest survival rates occur with fish that get out of the system very early (April-May) (Lindley et al. 2009, Sturrock et al. 2013, Mesick personal communication).
- Recovery efforts may need to examine how to improve rearing condition to get larger fish, earlier, and expedite their migration out of "harms way."
- If thermal refugia could be provided on the Stanislaus to Mossdale, the extent to which it would provide any population level effects and increased life history diversity are limited by the low likelihood of juveniles surviving once they left the Stanislaus River (lower San Joaquin and through Delta).

Questionable Feasibility

- There is a significant question of attainability of adequate quality for aquatic life from groundwater pumping (Mathany et al. 2013). Table 4 argues for non-suitability of groundwater water quality for temperature and dissolved oxygen. Toxics remain constituents of interest. Water treatment may be needed at substantive costs.
- The approach has not been done before (no research to indicate its feasibility). Is clear that the lower Stanislaus reaches being considered are amenable to habitat structural changes (large woody debris, floodplain habitat, riparian habitat). What types of habitat engineering is needed? Environmental concerns? Costs?

- Similar to dams blocking fish passage, the Stanislaus River aquatic/riparian landscape may have been irrevocably altered to prevent this re-creation of thermal refugia.
- 2000 cfs is 897,000 gpm or almost 1,000,000 gallons a minute. A 10,000 gpm groundwater pump would be huge, and constitutes about 10% of Vernalis flow. Is this possible and what are the impacts on groundwater resources? Would it even be possible to create thermal refugia in the San Joaquin River?

Alternatives/Improvements to the CM:

- The alternative of piping cold water from upstream cold water pool (New Melones) may provide appropriate volumes and quality of water over groundwater sources.
- Habitat modification (e.g. increased cover, woody debris, etc.) could provide similar refugia benefits for juveniles. [*Comment from authors: Does the lower Stanislaus have a bit of shading from riparian encroachment?*]

General Comments on the Sep

- SEP process issue: the process spent a lot of time on evaluation of selected CMs (selection process somewhat unclear), rather than thoroughly identifying, vetting, and rigorously selecting "most important" CMs.
- CMs not linked to specific, measureable outcomes that will have identified benefits for the goals (e.g. salmon doubling).

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Appendix A: Summary Tables Organized by Outcome

TABLE A1
POSITIVE OUTCOMES

Standarized Outcomes for Stanislaus River SEP		Scoring	
Standard Outcome Code	Outcome (brief descriptor)	Magnitude	Certainty
Habitat - Spatial Extent			
P1A&B	Habitat extent and conductivity	2	1
P3	Rearing	1	1
Habitat Quality			
P9	DO	2	1
P11	Water Temperature	2	1
Mortality			
P16	Temperature	2	1
Life History			
P21	Increase life history diversity (or diversity of outmigration)	2	1

TABLE A2
NEGATIVE OUTCOMES

Standarized Outcomes for Stanislaus River SEP		Scoring	
Standard Outcome Code	Outcome (brief descriptor)	Magnitude	Certainty
Mortality			
N3	Sink	2	2

		Worth		Risk	
Standard Outcome Code	**Outcome (brief descriptor)**	**Grade**	**Numeric**	**Grade**	**Numeric**
Habitat - Spatial Extent					
P1	Connectivity of habitat	Low	1		
P3	Rearing	Low	1		
Habitat Quality					
P9	DO	Low	1		
P11	Water Temperature	Low	1		
Mortality					
P16	Temperature	Low	1		
N3	Sink			Med	2
Life History					
P21	Increase life history diversity (or diversity of outmigration)	Low	1		

CM 04: WATER TEMPERATURE

Scientific Evaluation Process (SEP) Worksheet

Table of Contents

Conservation Measure Description

In 2004, a CALFED peer review panel (panel) convened to develop temperature objectives for the Stanislaus River (Table 1) [*Need citation*] to be used in conjunction with the CALFED water temperature model (Deas et al. 2004). Seven day average daily maximum (7DADM) criteria (US EPA 2003) were recommended by the panel to describe coldwater temperature conditions for protection of each salmon life stage, and the panel reviewed existing monitoring data to recommend dates and locations for the objectives. The CALFED temperature model and the objectives recommended by the panel provide a valuable approach to understanding how water temperatures may be improved, but the objectives were never intended to be used as water quality standards.[1]

More recently CDFW proposed water quality standards for the Stanislaus River in response to the Central Valley Regional Water Quality Control Board's Public Solicitation of Water Quality Data and Information for 2008 Integrated Report– List of Impaired Waters and Surface Water Quality Assessment [303(d)/305(b)] (Table 1; Loudermilk 2007). As with the panel recommendations, temperatures proposed by CDFW are also 7DADM temperatures identified in EPA 2003. However, unlike the panel, the dates, temperatures, and locations indicated by CDFW were intended to be water quality standards, not objectives. In addition, EPA 2003 does not include 7DADM for smoltification. Instead, table 1 in EPA 2003 lists a range from <12°C-15°C for constant temperature (laboratory) that would presumably translate to a higher 7DADM, i.e. > 15°C

- **Outcomes:**
    - Improve temperatures for fall-run Chinook salmon (salmon) smoltification.
    - Improve salmon survival.
    - Improve salmon abundance.
    - The measure may have benefits for other species such as steelhead, but these benefits were not considered as part of this evaluation.

TABLE 1
CALFED PANEL OBJECTIVE AND CDFW
PROPOSED WATER QUALITY STANDARD FOR CHINOOK SALMON SMOLTIFICATION.

	Dates	Lifestage	Optimal Temperature	Location
Panel	Apr 16 - Jun 3	Smoltification	< 15°C; <59°F	Confluence
CDFW	Mar 15 - Jun 15	Smoltification	< 15°C; <59°F	Confluence

- **Action:**
    - Meet CDFW proposed water quality standard of 15°C (59°F) to the confluence (seven day average daily maximum [7DADM] values) for smoltification during May 15 through June 15.

- **Approach:**
    - Provide up to 1,000 cfs daily in addition to existing flow during May 15-June15 to meet the CDFW proposed water quality standard of 15°C (57°F) to the confluence. Additional flow is assumed to come from additional discharge at

[1] Water Quality Standards define the goals for a water body by designating its uses, setting criteria to measure attainment of those uses, and establishing policies to protect water quality from pollutants. They are enforceable under the Clean Water Act (Title 40, part 131). Water Quality Objectives or Criteria are generally used in the planning or scientific study process to set definable targets for research/explanation to evaluate, investigate or understand. They would not be enforceable under federal or state water law. The US EPA Region 10 report provided guidance to States and Tribes on setting Clean Water Act standards, not setting the standards in the report. In order for objectives to become standards, they must be adopted by a State or Federal Water Quality Control Agency or Tribal authority.

Goodwin Dam. See clarifying assumptions section below on how this approach was evaluated.

- **Background:**

  Existing spring pulse flows [current NMFS Biological Opinion Reasonable and Prudent Alternatives (RPAs); occur March 15-May 15] appear to adequately address temperatures during this earlier period.

SEP Evaluation of the Conservation Measure

Evaluation Team

Lead Author:	John Cain (American Rivers)
Support Authors:	Julie Zimmerman (USFWS), and Michael Martin (Merced River Cons Comm)
Reviewer:	Rachel C. Johnson (USBR)
Workshop Participants:	Jeanette Howard (TNC), Andrea Fuller (FISHBIO); Eric Ginney (ESA) (notes)

Date of Evaluation Workshop; time CM was evaluated

04/09/2013

Modifications to the Conservation Measure

None.

Clarifying Assumptions

- For the purposes of this exercise, the team assumes that some amount of additional flow will meet the temp targets. Modeling analysis, however, suggests that it is unlikely that 1k cfs will be sufficient to meet the temperature target. The evaluation assumes the target can be met and focuses on characterizing the magnitude and certainty of benefits that would derive from achieving the target.
- AD Consultants and RMA, Inc. (2013) conducted a modeling analysis using HEC-5Q and prepared a technical memo summarizing results. The AD/RMA modeling assumptions and analysis was not peer reviewed. The results of the modeling analysis indicate that the 7DADM could be met at the confluence up to 44% of the period May 15 to May 31 with 2,000 additional cfs (May 15 to May 31). A lesser quantity of water and extending the additional 2,000 cfs later in the month was less successful at meeting the 7DADM criterion.
- Although releases of 1,000 or 2,000 cfs would not meet the 59 degree F objective most of the time, it would reduce the 7-day average temperature significantly below the base conditions. A release of 2,000 cfs would reduce temperatures below 61 degrees F eighty percent of the time. We did not evaluate whether this reduction would be sufficient to

facilitate successful smoltification or whether the 7-day average is the appropriate averaging period. More analysis of the literature regarding temperature tolerances is necessary to judge whether a reduction from over 65 7DAMDT degrees F to 62 degrees 7DAMDT is would yield significant benefits (Figure 1)

- In addition, this evaluation does not consider the salmon emigration survival benefits at might accre from increased flow through the Delta, because 1) the evaluation does not include the Delta and 2) as discussed above, the amount of additional releases is not specified.

%EXC	BASE	PLUS_1000	PLUS_2000	303(d) Temperature Target
2%	59.6	58.3	58.1	59.0
4%	60.1	58.5	58.3	59.0
6%	60.7	58.6	58.3	59.0
8%	61.0	58.7	58.5	59.0
10%	61.8	58.8	58.5	59.0
12%	62.0	58.9	58.6	59.0
14%	62.2	59.0	58.6	59.0
16%	62.2	59.1	58.7	59.0
18%	62.4	59.2	58.8	59.0
20%	62.7	59.4	58.8	59.0
22%	62.8	59.4	58.8	59.0
24%	63.0	59.5	58.9	59.0
26%	63.2	59.6	58.9	59.0
28%	63.2	59.6	59.0	59.0
30%	63.4	59.8	59.0	59.0
32%	63.5	59.9	59.1	59.0
34%	63.8	60.0	59.2	59.0
36%	64.0	60.1	59.2	59.0
38%	64.2	60.2	59.3	59.0
40%	64.6	60.2	59.3	59.0
42%	64.9	60.4	59.4	59.0
44%	65.0	60.6	59.4	59.0
46%	65.5	60.8	59.5	59.0
48%	65.9	60.9	59.5	59.0
50%	66.2	61.1	59.6	59.0
52%	66.7	61.1	59.6	59.0
54%	66.9	61.3	59.7	59.0
56%	67.2	61.4	59.8	59.0
58%	67.6	61.5	59.8	59.0
60%	67.8	61.7	60.0	59.0
62%	68.0	61.8	60.0	59.0
64%	68.1	61.9	60.1	59.0
66%	68.4	62.0	60.2	59.0
68%	68.6	62.1	60.3	59.0
70%	69.0	62.2	60.3	59.0
72%	69.3	62.4	60.4	59.0
74%	69.5	62.5	60.5	59.0
76%	69.7	62.7	60.6	59.0
78%	69.9	62.8	60.7	59.0
80%	70.1	62.9	60.8	59.0
82%	70.6	63.2	61.0	59.0
84%	71.6	63.5	61.2	59.0
86%	72.5	63.6	61.4	59.0
88%	73.2	63.9	61.6	59.0
90%	74.0	64.3	61.8	59.0
92%	74.7	64.9	62.3	59.0
94%	76.4	66.5	63.4	59.0
96%	78.2	75.2	75.2	59.0
98%	79.5	79.2	79.6	59.0
100%	80.7	80.8	81.2	59.0

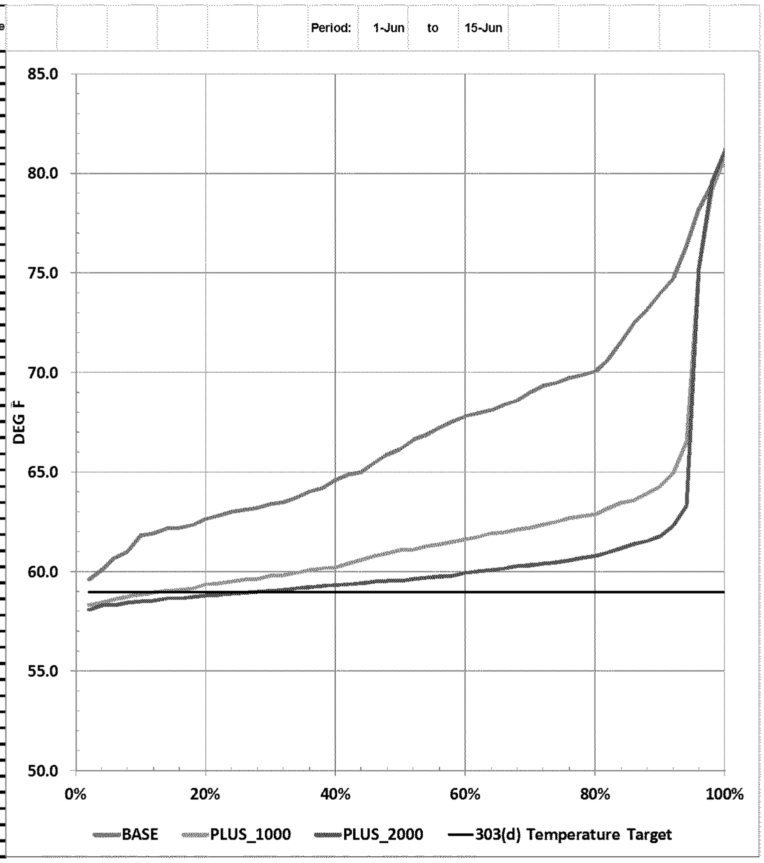

Figure 1. Temperature modeling analysis

Notes taken During Evaluation Workshop

- Confusion in the group on standards versus criteria: ultimately, deemed irrelevant because we are simply treating these as targets that will cause an effect on in-channel conditions that affect the fish.

- Important observation of the group: the evaluation group did not initially have numerical modeling data to determine whether adding up to 1k cfs will meet the temperature targets. Andrea and Ramon both share the opinion that out towards June 15 even an additional 1k cfs may not be sufficient to meet the temp targets. Subsequent modeling analysis described in clarifying assumptions section above indicates that 1,000 cfs would not be sufficient to meet the temperature objective.

- Literature related to smoltification and temperature relationships come from: Loudermilk□ EPA□ PNW studies. It is a composite target for optimal smoltification.

- Key observation is that lowering temp during the CM's stated time period in all years may not be the best use of water. It may be better to encourage fish to migrate earlier so that they can better avoid high temperatures and predation downstream in San Joaquin River and Delta.

Scale of Action- Large

Rationale:
The scale of this action is large because the action, by definition, would provide suitable tempertatures throughout a long reach of river (57 miles).

In wet years more fish are staying longer (smolting later) perhaps because the water is colder and they grow slower, or because there is more habitat, or because they are cued by warmer water. Why do fish smolt?

Evaluation Summary

Outcome P1: Increased Habitat Extent & Connectivity

Clarifying Assumptions:

- This section evaluates the increase in habitat extent and connectivity, and the population level impact of that increase for Chinook salmon only.

Scientific Justification:

- **Magnitude #4/3:** Providing cool water (59 degrees F) all the way to the confluence would clearly have a "landscape scale habitat effect" by significantly lowering water temperature along 57 miles of river. Lowering water temperatures for 30 days during late spring throughout a long reach of river could have significant impact for many species, but we have not evaluated those potential impacts in this analysis. Cooler temperatures would allow juvenile salmon to remain in the river longer and over a longer stretch of river, but it is unclear whether allowing juveniles to remain in the river longer would provide a population level benefit for Chinook salmon.

  The action will extend the period with suitable smoltification habitat and conductivity (along the smolt migration routes), by providing more optimal thermal conditions during the late migration period. A thermal barrier to migration (after smolitification) may occur in Dry and Critically Dry years when temperatures in the lower Stanislaus River and in the San Joaquin River may exceed 18 C. Table 7-12a in the SED (SWRCB 2012) shows the Maximum Daily Water Temperatures and the Percent of Time that Specified Water Temperatures were Exceeded in the Stanislaus River for each month between 1980 - 2003. EPA (2003) criterion were exceeded 70% of the time in April and 90% of the time in May. Action III.2 of the OCAP BO to provide coldwater for steelhead at Orange Blossom Bridge (table 2 below) should provide suitable water temperature for smoltification of fall-run Chinook through much of the spring into the lower Stanislaus if not all the way to the confluence and only until May 31st. Action III.1.2. Provide Cold Water Releases to Maintain Suitable Steelhead Temperatures

Criterion and Temperature Compliance Location	Duration	Steelhead Life Stage Benefit
Temperature below 56°F at Orange Blossom Bridge (OBB)	Oct 1*-Dec 31	Adult migration
Temperature below 52 °F at Knights Ferry and 57°F at OBB	Jan 1-May 31	Smoltification
Temperature Below 55°F at OBB	Jan 1-May 31	Spawning and incubation
Temperature below 65°F at OBB	June 1-Sept 30	Juvenile rearing

*This criterion shall apply as of October 1 or as of initiation date of fall pulse flow as agreed to by NMFS.

Fish that rear longer will presumably grow larger before outmigration [*no citation identified*] and larger smolts are more likely to successfully survive their migration to the ocean and back (Woodson et. al., in print).

- **Certainty #2:** Fuller et al. (2012), however, argue that most of the population of smolts (90%) has already migrated before this time (June). They also indicate that temperatures in the lower River and Delta will exceed EPA criteria[2] during June.

  It is unclear whether the action will be beneficial or harmful in some years, and even if it is beneficial, it is unclear how large a population level effect the action could have. In drier years in particular, the action could cause juveniles to rear longer only to face a higher probability of mortality in the San Joaquin River during a later migration (Fuller et. al., 2012). Fuller et. al. also argue that increasing flows to achieve target in the Stanislaus River will have little to no effect on water velocities, water temperatures, or predation in the Delta, where any remaining smolts from the Stanislaus would be located in June. They argue therefore, any fish that remain in the river to benefit from the action would likely be subject to higher mortality in the Delta.

  Review of migration timing and expected location of Stanislaus smolts indicates potential benefits to a small percentage of the smolt population in dry years, but as many as 35 percent of smolts in wet years. Although the percentage of smolts that currently remain in the river past May 15 is currently relatively small (<11 percent in 60 percent of the years and 25-35 percent in the wettest 40 percent of years), their contribution to the overall population may be significant, or a larger percentage of smolts may remain with the action and successfully migrate due to larger size. On the other hand, if most of the population migrates before May 15, then the measure will provide little benefit (and little risk) to the population.

Outcome P3: Additional Rearing Habitat

Scientific Justification:

- **Magnitude #3:** Scores for this outcome are identical to P1 and P3 for similar reasons: it could sustain a minor population effect and it will effect a large area (57 miles of river). It will only benefit that portion of the population that does not migrate out before May 15 and the population level benefits of enhancing

2 They cite US EPA (2003) as the basis for listing of the San Joaquin River as temperature impaired suggest that seven day average daily maximum (7DADM) temperatures should be less than **18°C for smolt outmigration**, or less than 20°C in the lower part of river basins that likely reach this temperature naturally.

conditions for this fraction of the population are uncertain (see uncertainty score below).

The measure clearly increases the duration of suitable rearing habitat conditions by providing more optimal thermal conditions during the very late rearing period. In years with high flows, and suitable temperatures, up to 35% of the fish that leave as smolts, leave after May 15 (Fuller et al. 2012, Martson 2007). Fuller et al. (2012) reports that ***smolt migrants*** remain near freshwater spawning areas for several months, migrating primarily from the tributaries during April and May and passing quickly (i.e., approximately seven days) through the Delta.

Other studies indicate the desirability of NOT prolonging (or extending) rearing. Baker and Morhardt, 2001 believed that getting *larger* smolts through the lower rivers and Delta *faster*, rather than slower, results in increased survival (emphasis added). This measure will allow the fish to grow larger before migrating, but it will also delay their migration.

- **Certainty #2:** Understanding is medium and nature of the outcome is highly dependent on highly variable ecosystem processes or other external factors such as Delta conditions, tributary flows, and Delta diversions. Fish that rear longer will presumably grow larger, but it is unclear how important the fraction of the population that benefits will contribute will to the overall population. One additional complexity, is that fish can rear natally or non-natally and presumably reach the same size or have the same growth rates before migration through the Delta. This is a key area of interest and uncertainty. For example, a feather river fish can leave as a fry enter the Yolo Bypass and potentially reach a larger size or have higher growth rates than staying in the Feather River and rearing to smolt size.

  It is also unclear how large a fraction of the population will benefit: by some measures and in some years, less than 1 percent of the population will benefit (Fuller et. al. 2003). By other measures, 30 percent of the smolt migrate after May 15 (Martson 2007). Lastly, and most importantly, successful migration to the ocean is highly dependent on conditions in the Delta which vary greatly by year type, ambient temperature, and water project operations in the Delta.

Outcome P6: Reduce Habitat for Predatory Fish and Long-Term Predation Mortality for Chinook Salmon

Scientific Justification:

- **Magnitude #3:** This measure would potentially have a sustained population level effect and change conditions over a large area for one month per year. Longer rearing would presumably result in larger juvenile outmigrants and cooler temperatures would improve condition of juvenile outmigrants, making them less susceptible to predation and other mortality factors (Myrick and Cech (2001) through a number of mechanisms including faster swimming speed, gape limitations on predators, higher energy reserves to avoid food scarcity, and reduced disease. Cooler temperatures would reduce the metabolism, feeding, and effectiveness of predator fish *in the Stanislaus River* [*Need citation*]. As noted in the certainty section and the negative outcome section, improving conditions in the Stanislaus would probably result in later migration and this delay could increase mortality from predation in the lower San Joaquin River and Delta.

Introduced and native predator species have thermal preferences that are higher than salmon (DFG, 2010): "As thermal optima for salmon/steelhead/rainbow trout are exceeded at temperatures above 64 to 65°F (17.7 to 18.3°C), major predators like pikeminnow, striped bass, and black bass are just entering their thermal optima. As cold water fish become stressed at temperatures above 64°F, salmon and trout become more vulnerable to predation." Other factors, including predation, disease susceptibility (parasites/pathogens), and low dissolved oxygen interact to make juvenile salmon more vulnerable to predation. Myrick and Cech (2001) report that few studies of indirect effects have been conducted in this area; the single laboratory study on Central Valley chinook salmon demonstrated that juveniles reared at temperatures between 21 and 24°C were more vulnerable to striped bass (*Morone saxatilis*) predation than juveniles reared at lower temperatures. Maximum daily consumption of juvenile salmon by fish predators like pikeminnow (*Ptychocheilus spp.*) and bass (*Micropterus spp.*) also increases with temperature. Known indirect effects include the increased vulnerability of juvenile salmon to fish predators following infection with *R. salmoninarum*. More research is clearly needed in this area, given the ongoing losses of juvenile salmon to fish and avian predators.

This measure could potentially score a 4 on this outcome if cold water in late spring reduced reproductive success of predator fish and significantly reduced predator populations [*Citation needed*].

- **Certainty #2/3:** *Note from Authors: need to verify whether literature from system is sufficient to give this a 3.]*

Understanding is medium to high and nature of outcome is largely unconstrained by variability in ecosystem dynamics or other external factors. There is high understanding of the mechanisms: cool water conditions improve the condition of juvenile salmon and reduces the activity of predators. There is high uncertainty, however, regarding how many fish would migrate later and what type of predation and entrainment pressures they may face in the Delta. As noted in the negative outcome section of this evaluation, improving conditions on the Stanislaus would probably result in later migration and this delay could increase mortality from predation in the lower San Joaquin River and Delta.

Colder water temperatures reduce metabolic rates and rates of predation. Temperatures that are optimal for salmon smolts are below optimum for predator species, so theoretically colder temperatures should lower predation rates on salmon. Understanding is medium to high, but nature of outcome is dependent on highly variable ecosystem processes. For example, although lower temperatures associated from increased flows should reduce predation, Fuller et al. (2012) cited a study which showed a positive correlation between and introduced predator, striped bass [*Note from authors: numbers?*], and higher river flows. Myrick and Cech (2001) report that few studies of indirect effects have been conducted in this area; the single laboratory study on Central Valley chinook salmon demonstrated that juveniles reared at temperatures between 21 and 24°C were more vulnerable to striped bass (*Morone saxatilis*) predation than juveniles reared at lower temperatures. Maximum daily consumption of juvenile salmon by fish predators like pikeminnow (*Ptychocheilus spp.*) and bass (*Micropterus spp.*) also increases with temperature. Known indirect effects include the increased vulnerability of juvenile salmon to fish predators following infection with *R. salmoninarum*. More research is clearly needed in this area, given the ongoing losses of juvenile salmon to fish and avian predators.

Most of the temperature studies have been conducted in the laboratory. Because field studies are not available, there is some uncertainty of the application of laboratory studies to the field. Review of migration timing and expected location of Stanislaus smolts indicates potential benefits may only accrue to a small percentage of the smolt population. Increased cold water habitat in the lower Stanislaus and San Joaquin Rivers could "push" predators downriver to Delta, and "concentrate" predator densities, thus exposing the earlier-migrating smolts to increased predation (overall population loss).

New Outcome P22: Increase Survival of Chinook Salmon during Outmigration.

The original evaluation team identified the following three outcomes which we have now lumped into this newly described outcome:

- **Outcome P11:** Contributes to conditions with water temperatures appropriate for salmon smoltification and smolt migration
- **Outcome P16:** Decreased mortality from excessive temperatures
- **Outcome P20:** Increase juvenile chinook salmon size at migration.

Scientific Justification:

- **Magnitude #3:** Scores for this outcome are identical to P1 and P3 for similar reasons: it could sustain a minor population effect and it will affect a large area (57 miles of river). It will only benefit that portion of the population that does not migrate out before May 15 and the population level benefits of enhancing conditions for this fraction of the population are uncertain (see uncertainty score below). The measure will allow fish to rear longer before smolting and therefore presumably emigrate as larger(cite), healthier smolts. Larger, healthier smolts are more likely to survive their migration to the ocean, but a later migration could subject the fish to higher temperatures, predation levels, and entrainment in the Lower San Joaquin Delta (see negative outcome X below).

  This measure could have sustained population level effect on a portion of the population *but only if* conditions in the Lower San Joaquin and Delta are suitable for migration during the later migration window. It may increase juvenile Chinook salmon size at emigration (smolts) if the proper rearing temperatures and diet occur during the May 15-June 15 period and juveniles elect to stay and rear instead of smolt and leave. Data from wet years suggest that fish stay much longer during wet years (cite) when flow is higher and temperatures are lower. This prolonged residency could be cued entirely by temperature, or alternative, could be triggered by better food and edge habitat conditions.

Strong smolt year classes are essential to maintain population viability and strong adult recruitment (Lindley et al. 2009). Increased stress levels, causing reduced survival of juveniles within tributary nursery habitats and reduced smolt migration from elevated water temperatures were suggested by Loudermilk (2007) as factors "in the continued decline in adult salmon escapement abundance in the . . . Stanislaus. . ." AFRP (2005) discussed survival of fry and parr migration in the lower Stanislaus River stating that it is "highly dependent upon flow(s) between March and early June." During normal and wet years, "many more fry, parr, and smolts were captured at the Caswell trap (RM 5) than the upstream Oakdale trap (RM 40), when flows at Ripon in February and March ranged between 1000 and 5000 cfs during above normal and wet years (1998-2000) than when it was less than 600 cfs during dry and normal years (2001-2004)" High flows in April, May, and June (normal and wet years) were responsible for the high survival rates of migrating smolts. "Supporting evidence is provided by the strong correlations between adult recruitment and Vernalis flows in March, April, May, and June."

Myrick and Cech (2001) reviewed temperature tolerances: "Chinook salmon subjected to acute temperature changes can tolerate temperatures as high as 28.8°C when acclimated to 19°C (Cech and Myrick 1999). Their ability to tolerate temperatures higher than the IULT (incipient upper lethal tolerance) is a function of exposure time, with an inverse relationship between exposure time and tolerated temperature. Chinook salmon chronic (> 7 days) upper thermal tolerance limits are remarkably similar to the IULT values discussed above (Table TT.1). Brett (1952) and Brett et al. (1982) found that the chronic upper thermal limit fell between 24.7 and 25.1°C for northern (WA and BC) chinook salmon races. In experiments by Rich (1987), American R. (CA) chinook salmon died after being held at 24°C for more than 8 days in river water. This temperature is lower than that tolerated by some northern stocks. Rich's result may stem from the effects of near–lethal temperatures, water chemistry/quality, and/or disease. Marine (1997) was able to rear Sacramento R. fall-run chinook salmon in well water at 21 - 24°C without significant mortality". The salmon chronic upper thermal limit of 25°C (77^{0}F) was exceeded at the confluence only **5 days** (6/5/2010-6/7/2010; 6/14/2010-6/15/2010) between June 3, 1999 and May 25, 2012 (**see** stantempcmsumtable mm.xlsx). Temperature modeling suggests that 7DADM exceed 24 degrees C less then ten percent of the time in late June. This suggests that acute mortality to juvenile salmon in the lower Stanislaus confluence is not a major problem, but more analysis of temperature data is necessary before finalizing this conclusion.

- **Certainty #2:** It is unclear whether the action will be beneficial or harmful in some years, and even if it is beneficial, it is unclear how large a population level effect the action could have. In drier years in particular, the action could cause juveniles to rear longer only to face a higher probability of mortality in the San Joaquin River during a later migration.

The laboratory temperature tolerance data on juvenile salmon and confluence temperature monitoring data predict virtually no risk from acute mortality impacts. The reliability of those data are high (published literature/CDFW temperature data). Minor uncertainty results from lack of field observations, but it is unlikely that mortality could be detected from surveys and direct field observations.

Outcome P20: Increase Juvenile Chinook salmon size at emigration

- **Magnitude #3**
- **Certainty #2:** The group would like more info on the balance between lower growth rates with cooler water and potentially-longer residence time which would potentially-yield a longer time of growth and hence larger emigrating fish. Scored a 2 for magnitude because of the small % of the population.

Outcome P21: Increase life history diversity (or diversity of outmigration)

Scientific Justification:

- **Magnitude #3**
- **Certainty #2:** This outcome scores the same as the previous outcomes for the same reason. If smolt stay longer and successfully migrate at larger size, then the measure will have increased the life history diversity time window. But if the smolt stay longer and then die, they will not create a new life history strategy. See negative outcome below.

N7: Increase the percentage (an absolute number) of juveniles that suffer mortality on their migration through the lower san joaquin river and delta

Scientific Justification:

- **Magnitude #3:** There is some risk that this measure may cause a sizeable portion of the population to migrate under less desirable conditions, and as a result, suffer higher mortality rates. The impact could have a sustained population level effect. Data and data analysis (cite) suggest that most salmon currently migrate as juveniles or smolts before May 15 in the drier 60 percent of years. But in wetter years when flows are also high on the Tuolumne, Merced, and Lower San Joaquin, 25-35 percent of smolt migrate after May 15. This data suggests that prolonging cool water releases in dry years could prompt a quarter of the population that emigrate as smolts to migrate late. If this migration occurs when flows are low and warm on the lower San Joaquin (no proportionately high contribution from other tributaries) then the smolt that migrate later could suffer higher mortality risks from predators, high temperatures, and entrainment into the Delta export facilities.
- **Certainty #2:** Understanding is medium and nature of the outcome is highly dependent on external variables such as flows from other tributaries and operations of the state and federal water project. If flows are high and diversions from state and federal water project are low, then predation and entrainment in the Delta will be relatively low and the larger, outmgrating smolts will have higher survival then smolt that migrate smaller (provide citation that large smolt are more successful). If, on the other hand, flows are low and temperatures and diversion are high, the late migrating smolt will face much higher risks of mortality despite their larger size.

Data Gaps, Key Uncertainties, New Ideas, and Suggestions for Future Planning

Data Needs:

None.

Key Uncertainties and Research Needs:

- More research on predation interactions with temperature, disease/pathogens in juvenile Chinook salmon
- The group (Outcome P20) would like more info on the balance between lower growth rates with cooler water and potentially-longer residence time which would potentially-yield a longer time of growth and hence larger emigrating fish
- Myrick and Cecj (2004) recommended a study to address Outcome P20 (Juvenile growth):

  "the effects of temperatures from the ILLT to the IULT and ration levels from sub-maintenance levels to 100% satiation. A study of this scale should be conducted for the major central valley Chinook salmon races, and would lead to the development of more accurate models of the effects of temperature and ration level on central valley salmon growth."
- Will keeping them in the river longer make them susceptible to predation and other mortality factors on migration through the Delta? Or will sending them out small and vulnerable make them more susceptible to mortality?
- What fraction of the population would benefit and what sustained impact would it have on the population? The impact on the population will depend to some extent on the relative success of early migrating fry vs. late migrating smolt: how important and effective is each lie history strategy? Success rate of fry is probably lower than the success rate of smolts.
- If fish are currently too small when they migrate, is it possible to manage reservoir releases and temperatures during the late winter and early spring to incubate and grow them faster before the onset of late spring. Manage temperature (investigate whether temperature is stratified). Evaluate releasing warm water in winter and saving cold water until later. Currently have unnaturally cold water in winter which may lead to slow incubation and growth.
  - Provide warmer water to optimize rearing in winter.
  - Determine whether New Melones is currently temperature stratified in the winter, if not, this idea wouldn't work.
- The measure will be more expensive and more risk in dry years when water is scarce and Delta conditions are more likely to be poor in June. Perhaps it makes sense to change the measure to meet standard in the wettest 40-60 percent years when there are good Delta conditions. In dry years, avoid the sink problems, and emphasize getting them out earlier.

- It may be prohibitively expensive or physically difficult to maintain temperatures of <15 degrees C between May 15 and June 15, but perhaps it is possible to significantly lower temperatures during this period without reaching the 15 degrees threshold. What type of benefits would accrue from meeting a 16 or 17 degree target instead of a 15 degrees target.
- What kind of diurnal variation or spatial refuges to temperatures exist on the river? The EPA temperature guidelines mention that a different 7DADM value may be warranted depending on the daily ranges in temperatures fish experience. If they are only experiencing temps >15 degrees C for 15 minutes, then this is different than 24 hours at >15 degrees C. Recommend exploring temperature variation specific to the Stanislaus River from a biological-fish refugia perspective.
- From a feasibility and fish physiology perspective, would releasing water sub-daily to mitigate the daily max be benefitical to fish if the diurnal temperatures in the evening and mornings are conducive to fish but mid-day is not?
- What is the basis of 7 DMDAT recommendation? Why 7 days? Presumably this is discussed by the initial CALFED panel referenced on page 1. We need to review the original CALFED panel recommendation.
- Otoliths can be used to test the management action of the role of prolonged cooler temperatures to the success of late outmigrating smolts. Fish can be sampled lower in the system (e.g., chipps island, golden gate) and identified to river of origin (Stanislaus River) and age/size/growth rate at Stanislaus River exit can be back-calculated by calendar date (e.g., May 30) and compared to similar Stanislaus River fish exhibiting different Stan river exit strategies that also survived to the golden gate. One can compare the contribution of different outmigration strategies (timing and river conditions of the survivors).

Important New Ideas or Understandings:

None.

Potential CM Re-configurations to Increase Worth /Decrease for Implementation

None.

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Appendix A: Summary Tables Organized by Outcome

TABLE A1
OUTCOMES

Standardized Outcomes for Stanislaus River SEP		Scoring	
Standard Outcome Code	**Outcome (brief descriptor)**	**Magnitude**	**Certainty**
Habitat - Spatial Extent			
P1	Connectivity of habitat	3/4	2
P3	Rearing	2	2
P4	Expand Spatial Distribution	2	2
P6	Reduce Habitat for Predatory Fish	2	2/3
Habitat Quality			
P11	Water Temperature	3	2
Mortality			
P16	Temperature	3	2
N7	Improved smoltification success and associated survival and escapement	3	2
Size			
P20	Increase juvenile chinook salmon size at emigration	3	2
Life History			
P21	Increase life history diversity (or diversity of outmigration)	3	2

Standard Outcome Code	Outcome (brief descriptor)	Worth		Risk		Worth		Risk	
		Grade	Numeric	Grade	Numeric	Grade	Numeric	Grade	Numeric
Habitat - Spatial Extent									
P1	Connectivity of habitat	High	3			Med	2		
P3	Rearing	Med	2			Med	2		
P4	Expand Spatial Distribution	Med	2			Med	2		
P6	Reduce Habitat for Predatory Fish	High	3			Med	2		
Habitat Quality									
P11	Water Temperature	Med	2			Med	2		
Mortality									
P16	Temperature	Med	2			Med	2		
P22	Increased Survival of Chinook Salmon during Outmigration	Med	2			Med	2		
N7	Increase the percentage (an absolute number) of juveniles that suffer mortality on their migration through the Lower San Joaquin River and Delta			High	3			High	3
Size									
P20	Increase juvenile chinook salmon size at emigration	Med	2			Med	2		
Life History									
P21	Increase life history diversity (or diversity of outmigration)	Med	2			Med	2		

CM 05: SPRING FLOOD FLOWS AND INUNDATED FLOODPLAIN

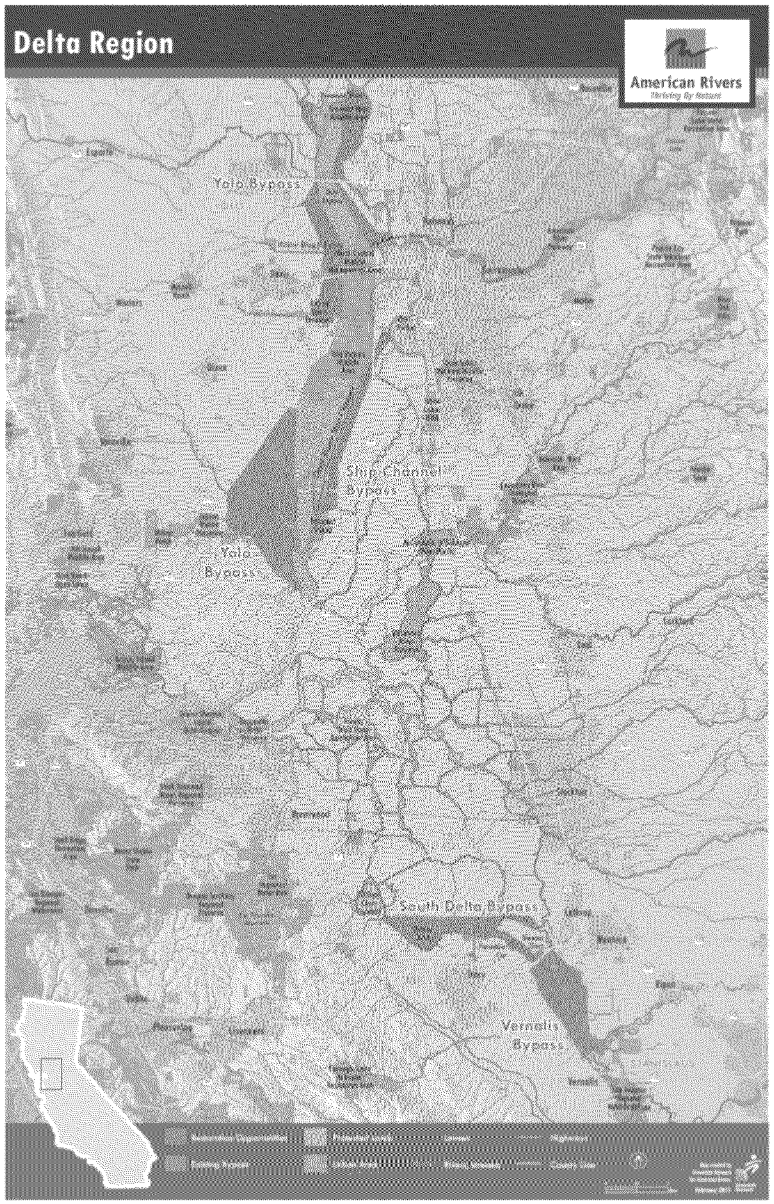
Scientific Evaluation Process (SEP) Worksheet

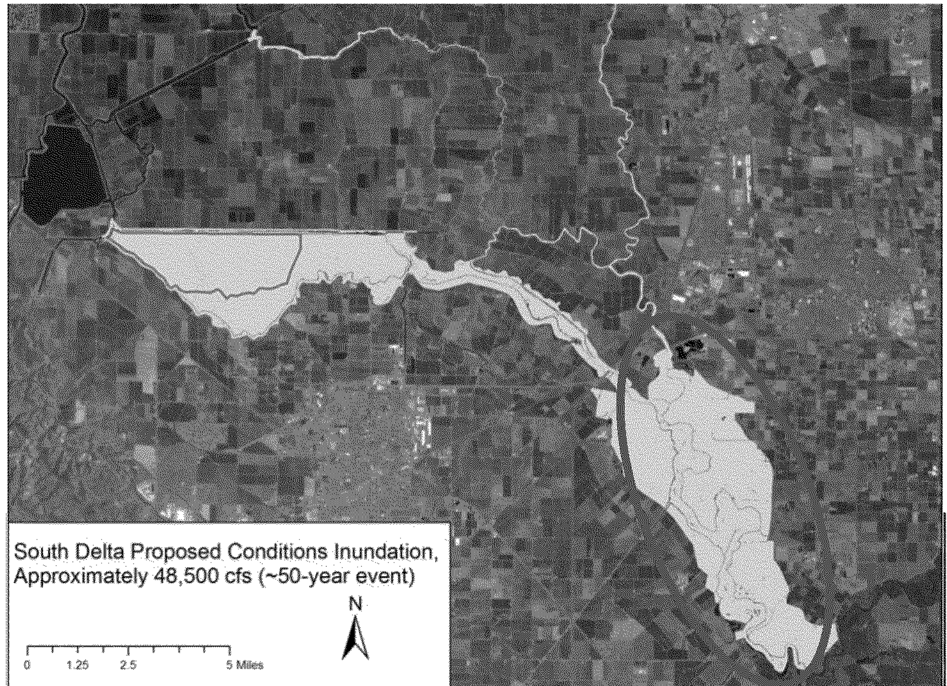
Table of Contents

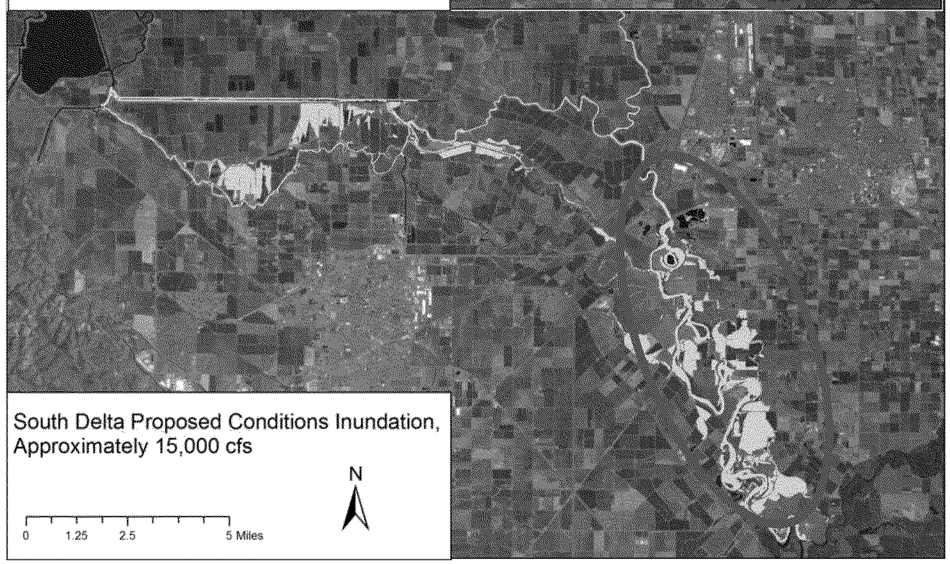
Conservation Measure Description

Inundated floodplain habitat on the Lower San Joaquin River between Vernalis and Mossdale is limited by both levees and flow regulation by upstream reservoirs. This conservation measure entails removing levees and increasing releases from New Melones (also assuming 11,000 cfs from upstream tributaries on the mainstem San Joaquin River) to create up to five thousand acres of inundated floodplain habitat between February 1 and May 31 in 67 percent of years for 14-28 days.

- **Primary Outcome:** Restore floodplain for juvenile Chinook salmon rearing to increase productivity, growth, and survival.
    - Implicit = increase juvenile Chinook salmon growth and survival
    - Alternate statement of outcome = Enhance juvenile Chinook salmon size at emigration to improve survival through the lower San Joaquin River, and Delta.
- **Secondary Outcomes:**
    - Implicit = Improve riparian habitat and cottonwood recruitment
    - Implicit = Increase channel habitat complexity
    - Implicit = Increase hyporeic flow and associated cold water refugia.
    - Implicit = Increase turbidity (biological turbidity) to reduce predation of outmigrating juveniles.
    - Implicit = Increase life history diversity by improving rearing conditions for fish that emigrate from the Stanislaus as fry and by lengthening the window of outmigration to the Delta and ocean so that fish do not all migrate at same time.
- **Action:**
    - Restore up to 5,000 acres of floodplain habitat along the Lower San Joaquin between Vernalis and Mossdale.
- **Approach:**
    - Remove levees between Vernalis and Mossdale, add large wood debris and/or raise channel invert to reduce channel capacity, and increase releases from New Melones to 3,500 cfs for 14-28 days in 67 percent of years.
    - Durations include:
        - 14 days in 20 percent of years
        - 21 days in 30 percent of years, and
        - 28 days in wettest 17 percent of years
    - Assumes 11,000 c.f.s. from upstream tributaries and mainstem.
    - Release water in pulses to inundate floodplain and then allow a few days of draining before releasing another overbank flow.
- **Background:**
    - A similar action was already evaluated using the SEP for BDCP's South Delta Habitat Working Group. This previous analysis only assumed setting back levees and did not entail changing upstream reservoir operations to increase the frequency of floodplain inundation.
    - The previous analysis indicated that the benefits of setting back levees were limited due to the low frequency of floodplain inundation (20 percent of years) caused by the existing, regulated hydrology of the San Joaquin River.
    - This conservation measure assumes changed reservoir operation (revised assumption that inundation was possible in 67 percent of years), which should modify previous SEP results.


Delta Region
American Rivers
Yolo Bypass
Ship Channel Bypass
Yolo Bypass
South Delta Bypass
Vernalis Bypass


South Delta Proposed Conditions Inundation, Approximately 48,500 cfs (~50-year event)
N
0 1.25 2.5 5 Miles


South Delta Proposed Conditions Inundation, Approximately 15,000 cfs
N
0 1.25 2.5 5 Miles

SEP Evaluation of the Conservation Measure

Evaluation Team

Lead authors:	Jeanette Howard (TNC) and Josh Israel (USBR)
Support author:	Ron Yoshiyama (UC Davis)
Reviewer:	Michael Martin (Merced River Cons. Comm)
Workshop participants:	Andrea Fuller (FISHBIO), John Cain (American Rivers), Jeanette Howard (TNC), and Eric Ginney (ESA)

Date of Evaluation Workshop; time CM was evaluated

4/10/2013; 11:15 AM

Modifications to the Conservation Measure

…create 5,000 of inundated floodplain habitat during the period February 1st to May 31st in 80 percent of years for at least 14 days and up to28 days in 20 percent of years.

- **Secondary Outcomes**
  - Implicit = Increase hyporheic flow and associated cold water refugia.
- **Action**
  - Restore ~~up to~~ 5,000 acres of floodplain habitat along the Lower San Joaquin between Vernalis and Mossdale.
- **Approach**
  - Remove levees between Vernalis and Mossdale, add large wood debris and/or raise channel invert to reduce channel capacity, and increase releases from New Melones to 3,500 cfs for 14-28 days in 80 percent of years.
  - In 20% of years (the driest), there is simply no action—the water is not made available.
  - Durations include:
    - 14 days in 80 percent of years
    - 21 days in 40 percent of years, and
    - 28 days in wettest 20 percent of years
  - Assumes 11,000 cfs from upstream tributaries and mainstem.
- **Background**
  - This conservation measure assumes changed reservoir operation (revised assumption that inundation was possible in 80 percent of years), which should modify previous SEP results.

Clarifying Assumptions

- Assume 5,000 acres will be made available with inundation schedule noted above.
- Assume that habitat created will be good habitat.

Notes taken During Evaluation Workshop

- This conservation measure involves setting levees back in low lying river between Vernalis and Mossdale. When run before for lower SJ don't get inundated floodplain habitat much because 80% of the hydrology is controlled by upstream reservoirs. Only get inundated floodplain once every 5 years. Want to change flow regime to increase frequency of inundation.
- If its 33% wet year or wetter WY, then the inundation happens.
- Assumes 11,000 CFS will be available from upstream river releases
- Discussion about whether to include water year type: development of flow regimes by water year type. Since floodplain inundation occurrence is based on water year type it was thought that this would be a useful framework – could assume inundation would happen in 3 wettest water year types.
- The 14-day inundation period is counted by inundation of the floodplain itself. Assume takes 10,000 cfs to inundate, need to saturate and get water over the floodplain. Not a lot known about how long it will take the floodplain to drain. After filling the floodplain could start to back off on the flow. Could be a constant flow – different from the existing pulse flow concept.

  Josh and John Cain exchanged a dialogue regarding exactly how often flow events would occur. The "2 out of 3 vs 9 out of 12" discussion was heard by all in the room. At first John agreed with Josh that it needed to be an exact 2 out of 3 years, but ultimately recommended that the group acknowledge natural variability and that indeed because of climatic conditions it could be the case that the prescribed flow events might not occur for 5 years or more. Ultimately, the 2 out of 3 years is a long-term, statistical average and that this frequency would be developed by allocating parcels of water based on WY type. Thus, if a critically-dry WY type occurred 5 years in a row, that would just be what happens.
- Hydrology is the key here. Floodplains are only floodplains if connected hydrologically to river.

Scale of Action

Rationale:
This is a large-scale action. 5,000 acres of floodplain habitat is very large and requires a large-scale ranking.

Evaluation Summary

Potential Positive Ecological Outcome(S)

Outcome P1: Increased habitat extent and connectivity

Scientific Justification:

- **Magnitude #4:** The frequency of inundation described in the CM is high frequency for a short-duration event and low frequency for a long duration event. While the optimal conditions would provide for a high frequency for a long duration event, the location of the Vernalis bypass at the landscape position just upstream of tidal South Delta reaches is an optimal spatial configuration. This outcome should be expected to contribute substantially to salmonid species' productivity, spatial distribution, and survival of diverse life history strategies. Other native species (i.e. splittail) will also realize increased abundance of larval and juvenile fishes due to potential increased spawning habitat.
- **Certainty #3:** While scientific understanding of linkage between river hydrology and floodplain habitat is high and supported by peer reviewed studies within the system [Sommer et al. 2001a,2001b (Yolo), Jeffres et al. 2008 (Consumnes)], limited hydrologic modeling demonstrating the assumptions are certain suggests that understanding of the outcome is based on highly variable climatic processes and uncertain external processes (regulatory flow negotiations).

Rationale:

Opperman 2013: "Tockner and Stanford (2002) characterize river hydrology as ''by far the single most important driving variable in floodplains.'' Floodplains are highly variable and heterogeneous systems due to the natural variability of river flows (Poff et al., 1997). Riverine hydrology exerts a strong influence on floodplain ecological and biogeochemical processes and, because river flows drive the processes of erosion and deposition that create floodplain topography, also shapes the physical template on which ecosystem processes occur (Poff et al., 1997; Ward et al., 2002). Hydrological processes influence floodplain ecosystems by controlling patterns of connectivity, residence time, and the flows that allow the exchange of organisms, carbon, and nutrients between portions of the landscape (). These linkages between hydrological processes and floodplain geomorphic and ecological processes are driven by a variety of flow levels and other hydrologic parameters. For example, long-duration, high-frequency flood events can be particularly important for food-web productivity and fish reproduction (Junk et al., 1989; Williams et al., 2009), while less frequent, higher magnitude events exert stronger influences on floodplain morphology (Trush et al., 2000)."

Limm and Marchetti (2009) found higher prey densities, and warmer water temperatures in both off-channel ponds and non-natal seasonal tributaries compared to the main-channel areas in both 2001 and 2002. Our findings suggest that warmer temperatures and abundant prey in off-channel habitats during Central Valley Chinook salmon rearing periods may lead to higher growth rates, which in turn may improve juvenile survival.

Outcome P3: Additional rearing habitat and distribution into historically occupied habitat areas

Clarifying Assumptions:

- This habitat area is probably very similar in some aspects to the Yolo Bypass floodplains.

Scientific Justification:

- **Magnitude #4:** Riverine rearing habitat is highly degraded in the lower San Joaquin River due to channelization and habitat conversion to slopes of levees for flood control. Riverine rearing habitat could be hypothesized to be the key limiting factor for salmonid growth prior to entering the Delta. Rearing habitat from this floodplain bypass will contribute substantially to salmonid population's productivity (hypothetically via increased carrying capacity), spatial distribution, and life history diversity. The location of the Vernalis Bypass is optimal for floodplain rearing habitat since all San Joaquin River salmonids must pass this area.

  It is known that juvenile growth rates are enhanced in low-elevation floodplains such as on the Yolo Bypass and lower Cosumnes River (Sommer et al. 2001b; Jeffres et al. 2008).Juvenile salmon will rear on seasonally inundated floodplains when available. Such rearing in the Central Valley, in the Yolo Bypass and the Cosumnes River floodplain, has been found to have a positive effect on growth and apparent survival of juvenile Central Valley salmon through the Delta. (Sommer *et al*. 2001**b,** Sommer *et al*. 2005 and Jeffres *et al*. 2008.) The increased growth rates may be due to increased temperatures and increased food supplies. Floodplain rearing provides conditions that promote larger and faster growth which improves outmigration, predator avoidance, and ultimately survival. (Increased survival may also be related to the fact that ephemeral floodplain habitat and other side-channels provide better habitat conditions for juvenile salmon than intertidal river channels during high flow events when, in the absence of such habitat, juvenile salmon may be displaced to these intertidal areas. (Grosholz and Gallo 2006) The improved growing conditions provided by floodplain habitat are also believed to improve ocean survival resulting in higher adult return rates. (Parker 1971)

  Connectivity is clearly increased. The extent is less clear: there is uncertainty on the quality of rearing habitat. However by increasing levee setback and engineering flood plain topographies, a more easily inundated and extensive floodplain would result with higher flow regimes. By engineering floodplains to be more "flow-friendly", a significant increase of previously occupied habitat would result.

- **Certainty #4:** The relationship between river flows and expanded floodplain rearing habitat is well understood in the Central Valley. Various peer reviewed studies on the Yolo Bypass (Sommer et al. 2001a, 2001b) and Consumnes River Preserve (Jeffres et al 2008) suggest rearing habitat is added simply by the river flow escaping the bankful height of the channel. In this CM, the levees will be set back to create opportunities for the flow to leave the channel. It is possible that landuse will not need to change outside the channel on the connected rearing habitat areas since it well understood that some types of agriculture (i.e. rice) and fish rearing habitat can coexist as demonstrated on the Yolo Bypass.

Rationale:

- Connectivity is clearly increased. The extent is less clear: there is uncertainty on the quality of rearing habitat.
- A lot of literature exists to support increasing floodplain habitat creates additional rearing habitat:
  - Limm and Marchetti 2009 - The primary result of the current study indicates that,Chinook salmon in the Sacramento River show larger otolith increments widths in off-channel habitats when compared to near-by main-channel habitat, suggesting faster or improved growth rates. Also increased prey availability.
  - Sommer et al. 2001 studies.
  - Opperman et al. 2010: Recent studies have also revealed that juvenile Chinook salmon (Oncorhynchus tshawytscha) have faster growth rates on floodplains than in main-stem river channels (Sommer et al. 2001b; Jeffres et al. 2008). Juvenile Chinook can enter and rear on floodplains during their downstream migrations in the winter and early to mid-spring. The juveniles have access to a diverse and dense prey base on floodplains – zooplankton density can be 10-100 times greater in a floodplain compared with the river (Grosholz and Gallo 2006) – along with generally more favorable habitat conditions (warmer, slower water, fewer predators).These conditions translate to faster growth compared with juveniles rearing in rivers. Faster growth rates allow juveniles to attain larger sizes when they enter the estuary and ocean, and body size has been found to be positively associated with survival to adulthood for salmonids (Unwin 1997).
  - Jeffries et al. 2008: While salmon growth gains increase with increasing duration of inundation, increased growth can be observed in as short as one to two weeks on the floodplain.

Outcome P5: Increased upstream migration opportunities

Clarifying Assumptions:

- Assume that some up-migrating adults may traverse the inundated floodplain instead of the main channel(s), but up-migration routes are currently not well known.

Scientific Justification:

- **Magnitude #1:** The timing of seasonal inundation of floodplain habitat between February 1 and May 31 is not during the peak or shoulder of adult salmonid migration on the San Joaquin River. A quick review of trap data from the Stanislaus River suggests 95% of Chinook salmon pass the Stanislaus River weir during the last week of November and first week of December (Pyper et al 1005). Thus existing literature indicates little effect.

- **Certainty #4:** There is a decade of San Joaquin River escapement timing data suggesting this CM does not have much effect on upstream migration opportunities. These studies have been completed for agencies as part of long term adult monitoring programs, and represent observational information. Since we have significant information on which to base our prediction of upstream migration and know migration is driven by fall temperatures, DO, and adult fish physiology, we are certain that floodplain creation does not affect any of these.

Outcome P7: Increased establishment of woody riparian vegetation providing shaded channel habitat, increased channel margin complexity, and export of large woody debris (LWD)

Clarifying Assumptions:

- This is a large area (7 square miles); it is landscape scale, and it is certain that all fish from the Stan will use it (regardless of flow; this aspect of the habitat is there year round).
- May take many years to establish riparian veg with sufficient floods.

Scientific Justification:

- **Magnitude #2:** 5000 acres of floodplain will include some woody riparian vegetation and channel margin capacity. It is unlikely to lead to export of large woody debris, but coarse wood could be easily swept into the flow. This habitat will likely exist in multiple patches within the 5000 acres.
- **Certainty #2:** Establishment of riparian habitat requires multiple processes to occur in particular spatial and temporal locations to understand where and how much of these habitats will become established. These processes include seed dispersal, seed germination and groundwater availability which we have no information concerning in this CM's approach. Since these processes are linked to biological processes (i.,e. vegetation biology) and physical process (i.e flow) the nature of the outcome is dependent on highly variable ecosystem processes not controlled by the CM.

  The floodplain maintenance flood is a higher magnitude flood capable of performing geomorphic work including bank erosion and deposition on the floodplain that creates and maintains floodplain surfaces and contributes to heterogeneous floodplain topography (Opperman et al 2010, Florsheim and Mount 2002). This type of flood quantity is not a maintenance flood event except perhaps adjacent to weir and flood bypass inlets and outlets (i.e. constrained locations). A heterogeneous topography result can result without maintenance flows in vegetation patches of varying age, species composition, and structure and floodplain waterbodies of varying successional stage and connectivity to the river (Ward et al. 2002).

Outcome P8: Increased establishment of emergent vegetation

Clarifying Assumptions:

- Spatial extent is limited—this vegetation type will be patchy and not a dominant part of the new floodplain. Uncertain how extensive it will be as current laws prohibit vegetation on levees.

Scientific Justification:

- **Magnitude # :3** 5000 acres of floodplain bypass are likely to be dominated by emergent vegetation and agricultural vegetation. This vegetation is likely be be represented by multiple large patches. Emergent vegetation is likely an important substrate for macroinvertebrates. These substrates may also be important for creating velocity refugia and hiding areas.
- **Certainty #3:** The importance of emergent vegetation as rearing habitat on floodplains has not been well documented, although Central Valley floodplains are predominantly this type of vegetation (and agricultural vegetation). Thus our understanding is medium. Given the quantity of land (5000 acres) it is likely to be a significant amount of emergent vegetation. Thus, the increased establishment is largely unconstrained by ecosystem dynamics or external factors. It is more likely to be limited by external factors such as agriculture and information about the predominance of this land use type vs. vineyards and other perennial crops in the area would be very useful information.

Outcome P10: Increased delivery of readily-suspendable sediments

Clarifying Assumptions:

- 5,000 acres of floodplain may serve as sediment sink. Assume outcome of improved habitat, greater feeding success and reduced predation is based on increasing delivery of readily suspendable sediments. Floodplain habitat would likely serve as sediment sink. The higher the flows the more positive the fluctuation from the long-term trend. It follows then that higher flows (under this Outcome) results in higher suspended sediment concentrations on the floodplain.

Scientific Justification:

- **Magnitude #1:** There is little existing literature indicating more than a little effect of increased delivery of readily suspended sediments due to floodplain reconnection. In fact, one reason primary productivity and rearing habitat are considered better on floodplain is due to reduced velocities and reduced turbidity compared to riverine channels (See certainty score).
- **Certainty #3:** Mechanisms leading to increased turbidity due to floodplains are not well understood. Opperman (2010) found that during periods of inundation, floodplains provide very different habitat conditions than found in the adjacent river channel. As flow moves from the river onto the floodplain water velocity generally slows considerably, allowing sediment to drop out of suspension. As a result, floodplain water is often less turbid than river water and can thus support greater rates of photosynthesis from aquatic vascular plants and algae (including both attached algae and phytoplankton) (Ahearn et al., 2006). This primary productivity in turn supports high productivity of zooplankton and aquatic invertebrates (Junk et al., 1989; Grosholz and Gallo, 2006).

Outcome P11: Contributes to rearing and migration habitat conditions with optimal water temperatures.

Clarifying Assumptions:

- Large-scale floodplain inundation would only help juvenile salmonids during the rearing phase.

- Scoring based on floodplain as rearing habitat.

Scientific Justification:

- **Magnitude #4:** The additional of 5000 acres may be expected to have a landscape level impact on temperature. This quantity of habitat and temperature increase is likely to influence productivity (growth rates of individuals), spatial distribution, and expression of life history diversity.

- **Certainty #3:** Peer reviewed studies in the Central Valley have observed larger average otolith growth increments, higher prey densities, and warmer water temperatures in both off channel ponds and non-natal seasonal tributaries compared to the main-channel areas in both 2001 and 2002. Findings suggest that warmer temperatures and abundant prey in off-channel habitats during Central Valley Chinook salmon rearing periods may lead to higher growth rates, which in turn may improve juvenile survival (Limm and Marchetti (2009). This may therefore also potentially increase predator densities, although certainty of predators occupying floodplain habitat uncertain.These studies do not provide much information about the spatial or temporal approaches to this action. Thus while our understanding of optimal temperatures for rearing and migration are known and appear to occur on floodplains, it is essential to consider the Vernalis Bypass. Temperatures in the mainstem Sacramento river can be up to 5 degrees warmers in the spring than the adjacent floodplain in April and May (Sommer et al. 2001b). In the Vernalis reach, temperatures can begin to reach suboptimal levels for salmonid rearing in late April, and thus added temperature due to floodplain depths and temperature times may in fact be detrimental to salmonids during this migration and growth period. The difference in temperature is in fact dependent on other highly variable ecosystem processes (climatic primarily), and thus certainty is Medium.

Outcome P12: Increased production and local availability of aquatic food resources (POM, phytoplankton, zooplankton, etc)

Clarifying Assumptions:

- Assume that inundation duration will be long enough to energize the food web—i.e., phytoplankton production to zooplankton to small fish.

Scientific Justification:

- **Magnitude #4:** The increased duration of water on inundated floodplain for at least 14 days is likely to provide a sustained major increase in aquatic food resources. This will likely contribute substantially to salmonid productivity via increased carrying capacity in the river and increased potential growth.

- **Certainty #4:** Numerous published Central Valley studies have shown that floodplains increase production of aquatic food resources (i.e. primary and secondary productivity) via inundation for at least 14 days (Sommer et a.l 2001b, Jeffres et al. 2008, Ahearn et al. 2006, Grosholz and Gallo 2006). It should be noted many of these studies found that more than 14 days is necessary to signficantly increase secondary productivity (i.e. zooplankton) and more than 28 days it typically needed for small fish increases (i.e. splittail and other larval species).

Outcome P13: Increased production of terrestrial invertebrates put into the aquatic ecosystem for rearing covered fish

Clarifying Assumptions:

- Assume that sufficient riparian vegetation will become established to provide allochthonous food (e.g., insects falling into the water).

Scientific Justification:

- **Magnitude: #2:** See Outcome P7 (see clarifying assumption here but also P8). The role of floodplain food production for salmonids is mainly through a detrital and algal food webs, not terrestrial. The 5000 acres created is likely to have numerous patches of riparian habitat supplying terrestrial invertebrates.
- **Certainty: #3:** The timing of terrestrial inputs into the floodplain foodweb is mainly controlled by presence of terrestrial invertebrates, which is linked to seasons, air temperatures, and other terrestrial ecosystem drivers (Nakano et al 1999). Thus the outcome's certainty is dependent on highly variable ecosystem processes not linked to the approach of this CM. There is little information from the Central Valley about terrestrial invertebrates as part of floodplain foodwebs. Jassby and Cloern (2000) indicate that phytoplankton from both autochthonous primary productivity and river inputs is the dominant primary food resource in spring and summer, which are critical seasons for postlarval development of fish.

Outcome P14: Food resources produced on the restored habitat will be exported and contribute to food availability in downstream aquatic areas. (Note: food resources could include organic carbon, phytoplankton, zooplankton, and other organisms)

Scientific Justification:

- **Magnitude #4**

Rationale:

In hydraulic food chain models, river food chains could sustain top predators only when the river biota had periodic access to floodplains. Inundation of floodplains facilitates and exchange of organisms, nutrients, sediment, and organic material between the river and floodplain, and provides a medium in which biogeochemical processes and biotic activity (e.g., phytoplankton blooms, zooplankton and invertebrate growth and reproduction) can occur (Power et al. 1996). This exchange of material can benefit downstream areas.Studies suggest phytoplankton, zooplankton, and other organic material transported from the Yolo Bypass enhances the food web of the San Francisco Estuary (Jassby and Cloern 2000; Mueller-Solger et al. 2002; Sommer et al. 2004.)

- **Certainty #2**

Outcome P15: Decreased nutrients (NPK, etc)

Scientific Justification:

- **Magnitude #2:** There is sufficient documentation that the lower San Joaquin/Delta is not nutrient deficient. The justification is connected to the lack of documentation or study (which is a certainty measure). Nutrient concentrations are not limiting, nor a driving factor, so the magnitude is scored low. See Jassby et al (2002) as cited in below.

The quantity of nutrients in the San Joaquin River is not well documented although it is likely high. The quantity of nutrients removed from the San Joaquin due to a Vernalis Bypass is unknown. More modeling is necessary to determine if the spatial and temporal reduction impact is greater than limiting a small quantity of nutrients.

- **Certainty #4:** There is peer reviewed articles from the Delta and floodplains (Lehman et a.l 2008, Jassby et al. 2002) that identifies floodplains typically decrease nutrients.

  Opperman 2013: During overbank flooding, floodwaters spread out on floodplains and, due to slower water velocities on the floodplain, much of the sediment in transport is deposited there. Because nutrients such as phosphorous are largely adsorbed to sediment particles, this deposition can reduce the loads of sediment and some nutrients in rivers and thus improvewater quality for downstream waterbodies, such as estuaries and near-shore marine habitats (Noe and Hupp, 2005). Floodplain reconnection and restoration of floodplain wetlands is therefore recommended as a strategy to reduce nutrient pollution to important waterbodies such as the Chesapeake Bay (Noe and Hupp, 2005) and the Gulf of Mexico (Mitsch et al., 2001). Owing to sediment deposition during recurrent overbank flooding, portions of floodplains can have deep, fertile soil, which can support productive forests (Brinson, 1990; Yarie et al., 1998). Thus, in addition to nutrient sequestration, floodplains can also sequester carbon within rapidly growing trees.

  However, any net change in nutrients that occurs, if any, may be inconsequential because Lehman et al. (2008) found that nutrient concentrations were generally not limiting for primary productivity on either the Yolo Bypass floodplain or in the adjacent Sacramento River channel.

  Lehman et al (2008, p.371): "Like YB [Yolo Bypass] concentrations of the major dissolved nutrients inorganic nitrogen, soluble reactive phosphorus and silica . . . were not limiting at SR [Sacramento River] (Jassby 2005)."

  Similarly, Jassby et al. (2002, p.698) stated, "The Sacramento-San Joaquin River Delta, . . . , has ample nutrient supplies, enabling us to examine alternate regulatory mechanisms over a 21-yr period."

Outcome P17: Reduced predation mortality (i.e. due to striped bass, black bass, and other non-native predatory species)

Clarifying Assumptions:

- Assume that predators of juvenile salmon will not "follow" the salmon onto the floodplain during inundation periods even though we expect pre densities to increase on the floodplain. This is somewhat counterintuitive and needs to be investigated.

Scientific Justification:

- **Magnitude #2:** This outcome is expected to only influence the small fraction of native fish that are entrained onto the bypass. While there is quite a bit of evidence that Central Valley floodplains are habitat for alien predator species (Sommer et al 2004, Harrell and Sommer 2003), it is likely these predators will not be as dense across the 5000 acres as they are along mainstem channelized riverine banks. This outcome does not influence productivity or diversity, only abundance.

- **Certainty #3:** The quantity of predators on a Vernalis Bypass will be related to the duration of flooding and water temperature, which will influence how hungry and how much predators will search for food. Based on other studies in the Central Valley enumerating presence of native and nonative fishes on floodplains (Sommer et al. 2004, Harrell and Sommer 2003), it is clear that alien fish are entrained onto floodplains, or perhaps may enter floodplains from downstream, if they are present in adjacent river reaches. Thus our understanding for the presence of alien fish presence is high. The quantity of predators is likely to be small, but water temperature is outside the control of the CM and influenced by highly variable ecosystem processes. Flooding in May is likely to lead to warm temperatures (See Outcome P11) Thus the nature of this outcome is dictated by other ecosystem process (i.e. climatic) that are outside the control of the CM.

Outcome P20: Increase Survival and growth of Chinook Salmon during floodplain occupation

Clarifying Assumptions:

- The original evaluation team identified the following three outcomes which we have now lumped into this newly described outcome:
  - Outcome P1: Increased habitat extent and connectivity
  - Outcome P11: Contributes to rearing and migration habitat conditions with optimal water temperatures
  - Outcome P20: Increase Juvenile Chinook salmon size at emigration

  Assume increased floodplain habitat and improved ecological conditions (food, cover, temperature, decreased predation) that juvenile condition and numbers would improve with this CM. This would increase survival and growth of individuals that would increase the survivability and numbers to smoltification. Increased population and migration of smolts would result in increased adult escapement populations.

Scientific Justification:

- **Magnitude #4:** The increased duration of water on inundated floodplain for between 14 and 28 days is likely to provide a sustained major increase in aquatic food resources. In turn, this will likely contribute substantially to salmonid productivity via increased juvenile habitat and increased potential growth. An additional 5000 acres of floodplain may be expected to have a landscape level impact on temperature, food, and supporting juvenile habitat. This quantity of habitat and temperature increase is likely to influence productivity (growth rates of individuals), spatial distribution, and expression of life history diversity. Juvenile salmon will rear on seasonally inundated floodplains when available. Such rearing in the Central Valley, in the Yolo Bypass and the Cosumnes River floodplain, has been found to have a positive effect on growth and apparent survival of juvenile Central Valley salmon through the Delta. (Sommer *et al.* 2001**b,** Sommer *et al*. 2005 and Jeffres *et al*. 2008.) The increased growth rates may be due to increased temperatures and increased food supplies. Floodplain rearing provides conditions that promote larger and faster growth which improves outmigration, predator avoidance, and ultimately survival. Increased survival may also be related to the fact that ephemeral floodplain habitat and other side-channels provide better habitat conditions for juvenile salmon than intertidal river channels during high flow events when, in the absence of such habitat, juvenile salmon may be displaced to these intertidal areas. (Grosholz and Gallo 2006) The improved growing conditions provided by floodplain habitat are also believed to improve smolt migration to the ocean, resulting in an increased ocean population resulting in higher adult return rates. (Healy 1982, Parker 1971)

- **Certainty #4:** The relationship between river flows and expanded floodplain rearing habitat is well understood in the Central Valley. Various peer reviewed studies on the Yolo Bypass (Sommer et al, 2001a, 2001b, 2004) and Consumnes River Preserve (Jeffres et al 2008) suggest rearing habitat is added simply by the river flow escaping the bankful height of the channel. In this CM, the levees will be set back to create opportunities for the flow to leave the channel. It is possible that landuse will not need to change outside the channel on the connected rearing habitat areas since it well understood that agriculture and fish rearing habitat can coexist as demonstrated on the Yolo Bypass.

Outcome P21: Increase life history diversity (or diversity of outmigration)

Clarifying Assumptions:

Scientific Justification:

- **Magnitude #3:** Only a small fraction of the population will likely use the floodplain. Thus, only a small fraction will be subject to the benefits of reduced predation, increased growth, etc. However, the CM addresses productivity, spatial distribution in sustained levels due to the frequency of inundation. Thus, this CM would be expected to create a more variable distribution of outmigration for a small fraction of the population but it is likely to have a sustained population level effect due to its spatial and temporal habitat effects**.**

- **Certainty #2:** The percent of fish using a floodplain described in the CM is unknown although the period of potential inundation overlaps only somewhat with when Chinook salmon are outmigrating (significant outmigration in late April and May typically past Mossdale, Mossdale trawl data). Since our understanding for when the floodplain activation would be synched with fish outmigration is unknown, our understanding in medium at best since releases for the action rely on uncertain external factors and fish migration depends on variable ecosystem processes.

Notes:If juveniles will actually use this newly expanded habitat, then more fry and parr that out-migrate or are swept out of the Stanislaus (and other tribs) during winter would be able to survive. This would bolster the early-spawning portion of the population.

Variability of timing could lead to greater life history diversity. Could be very significant if things worked right. Uncertain how frequently or heavily this floodplain habitat will be available and used due to annual variability in occurrence of the various water-year conditions.

Potential Negative Ecological Outcome(s)

Outcome N1: Increased habitat for non-native predators/competitors to covered species

Scientific Justification:

- **Magnitude #2:** While floodplain habitat is generally beneficial to salmon, it may also be detrimental under certain conditions. While there is quite a bit of evidence that Central Valley floodplains are habitat for alien predator species (Sommer et al 2004, Harrell and Sommer 2003) it is likely these predators will not be as dense across the 5000 acres as they are along mainstem channelized riverine banks. This outcome does not influence productivity or diversity, only abundance. Reduced depth may also make salmon more susceptible to predation. Water depths of 30 cm or more are believed to reduce the risk of avian predation (Gawlik 2002).

- **Certainty #2:** There is insufficient modeling results to know the depth or potential number of predators likely to be encountered on the Vernalis bypass. Since out understanding for predator habitat and denisties is not welll established, certainty is Low. Additionally, predation rates are likely controlled by temperature and existence of optimal habitats for predators. Since predation rates are dependent on variable ecosystem processes outside the control of the CM, there is more support for certainty being Low. As a result, as summer temperatures increase, floodplain habitat should also decrease.

Outcome N4: Increased stranding or entrainment mortality

Clarifying Assumptions:

- Assume that design is done to eliminate any anthropogenic stranding. Assume floodplain is engineered properly.

Scientific Justification:

- **Magnitude #2:** Study on Yolo Bypass (Sommer et al. 2005) showed that the Yolo floodplain did not pose significant stranding risk to salmonids and other native fishes as long as there were no unnatural features (artificial structures) that interfered with egress from the floodplain during falling water levels. However, areas with engineered water control structures have comparatively higher rates of stranding. (Sommer *et al.* 2005). In addition, high temperatures, low DO, and other water quality conditions that may occur on floodplains may adversely affect salmon.

- **Certainty #2:** There is no modeled footprint results or enumeration of water control structures to quantify stranding risks. Other floodplains that are not designed as fish friendly may cause stranding and we don't know if we can engineer it properly because we haven't done anything at this scale before Thus our understanding in Low. However, the most successful native fish are those that use the floodplain for rearing, but leave before the floodplain becomes disconnected to the river. (Moyle *et al*. 2007). Thus, it is likely that the nature of the outcome is not constrained by ecosystem dynamics and reflects fish behavioral cues.

Outcome N5: Potential for increased mercury methylation, local bioaccumulation and impact on covered species (on floodplain and downstream)

Scientific Justification:

- **Magnitude #2:** There is potential for increased mercury methylation with floodplain inundation (Henery et al. 2010). For this CM, the magnitude of the outcome is likely to be limited to a small fraction of the poulation and thus this has a Low Magnitude.

- **Certainty #3:** Without additional modeling of residence times, duration of wetting, and frequency of wetting we cannot be certain we understand the nature of the outcome. However, it is fair to note that peer reviewed literature in the system (Henery et al 2010) suggest that over long term period methylations will occur although it cannot be quantified without more information. Thus cout understanding is medium and since methylation rates is largely unconstrained by ecosystem dynamics or other external forces, certainty is Medium.

Data Gaps, Key Uncertainties, New Ideas, and Suggestions for Future Planning

Data Needs:

- Nutrients
- Predators
- Smolt outmigration – floodplain use, acoustic tracking of outmigrating smolts, how fast smolts move out
- Bruce McFarlane – body condition of smolts moving out through estuary into gulf of Farallones, definitely not feeding = moving out in a few days – gained weight in gulf FishBio studies

Key Uncertainties and Research Needs:

- Spawners use of floodplains.
- Smolts use of floodplains

- How long of an inundation period is needed to stimulate food production here?
- Mercury issues
- Fish agencies are reportedly tagging and tracking up-migrating adults in the Estuary-Delta but we don't know if any results have been obtained. This is a research need.

Important New Ideas or Understandings:

None.

Potential CM Re-configurations to Increase Worth /Decrease for Implementation

None.

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No references provided in original CM description.

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Appendix A: Summary Tables Organized by Outcome

TABLE A1
POSITIVE OUTCOMES

Standarized Outcomes for Stanislaus River SEP		Scoring	
Standard Outcome Code	**Outcome (brief descriptor)**	**Magnitude**	**Certainty**
Habitat - Spatial Extent			
P1	Connectivity of habitat	4	3
P3	Rearing	4	4
P4	Expand Spatial Distribution	4	3
P5	Upstream Migration	1	4
Habitat Quality			
P7	Shaded Channels /Channel Margin/LWD	2	2
P8	Emergent Vegetation	3	3
P10	Suspended Sediments	1	3
P11	Water Temperature	4	3
Food			
P12	Increased Local Aquatic Primary and Secondary Production	4	4
P13	Increased Terrestrial Invertebrates	2	3
P14	Food Export	4	2
P15	Nutrients	2	4
Mortality			
P17	Reduced Predation	2	3
Size			
P20	Increase juvenile chinook salmon size at emigration	4	4
Life History			
P21	Increase life history diversity (or diversity of outmigration)	3	2

TABLE A2
NEGATIVE OUTCOMES

Standarized Outcomes for Stanislaus River SEP		Scoring	
Standard Outcome Code	Outcome (brief descriptor)	Magnitude	Certainty
Habitat - Spatial Extent			
N1	Habitat for Predators/Competitors	2	2
Mortality			
N4	Increased Entrainment	2	2
Contaminants			
N5	Mercury Methylation	2	3

		Worth		Risk	
Standard Outcome Code	Outcome (brief descriptor)	Grade	Numeric	Grade	Numeric
Habitat - Spatial Extent					
P1	Connectivity of habitat	High	3		
P3	Rearing	HIgh	3		
P4	Expand Spatial Distribution	High	3		
P5	Upstream Migration	Med	2		
N1	Habitat for Predators/Competitors			Med	2
Habitat Quality					
P7	Shaded Channels /Channel Margin/LWD	Med	2		
P8	Emergent Vegetation	High	3		
P10	Suspended Sediments	Med	2		
P11	Water Temperature	High	3		
Food					
P12	Increased Local Aquatic Primary and Secondary Production	HIgh	3		
P13	Increased Terrestrial Invertebrates	Med	2		
P14	Food Export	High	3		
P15	Nutrients	High	3		

Mortality					
P17	Reduced Predation	Med	2		
N4	Increased Entrainment			Med	2
Contaminents					
N5	Mercury Methylation			Med	2
Size					
P20	Increase juvenile chinook salmon size at emigration	HIgh	3		
Life History					
P21	Increase life history diversity (or diversity of outmigration)	Med	2		

CM 06: INUNDATED FLOODPLAIN HABITAT

Scientific Evaluation Process (SEP) Worksheet-DRAFT

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Conservation Measure Description

Providing floodplain habitat for juvenile Chinook salmon in the Stanislaus River has been identified as a high priority action for the Anadromous Fish Restoration Program (USFWS 2001). Floodplains provide food resources, which contribute to faster growth rates for floodplain reared fish than fish rearing in the main river channel. The amount of juvenile Chinook salmon floodplain rearing habitat is dependent upon the San Joaquin Basin Water Year Type and instream flow releases downstream of Goodwin Dam in the Stanislaus River. Currently, there is no significant difference in the daily mean size of juvenile Chinook salmon produced across different water year types except in wet years (ANOVA, $P \leq 0.01$) for the Stanislaus River (Ramon Martin, In Prep). The assumption is that this increased size is a function of the increased inundated floodplain area and associated increases in both aquatic and terrestrial origin prey availability in those years. These findings, in combination with published findings from other central valley systems, suggest that increasing the amount of floodplain habitat available to juvenile salmon in the Stanislaus River at a variety of flow conditions could increase the overall size of juveniles and lead to higher survival (Sommer et al 2001, Jeffres et al 2008). In 2010, the U.S. Fish and Wildlife Service implemented an Instream Flow Incremental Methodology (IFIM) hydraulic and habitat modeling study for fall run Chinook salmon. In 2012, a model was developed to estimate the floodplain area versus flow in the Stanislaus River (Table 1). Floodplain rearing habitat was computed for flows up to 5,000 cfs. Additionally, a two-dimensional hydraulic model was developed to quantify the relationship between floodplain area and flow ranging from 250 to 5,000 cfs for the following four reaches of the Stanislaus River:

1. Confluence with San Joaquin River to Ripon (USFWS, In Prep);
2. Ripon to Jacob Meyers Park (Figure 1);
3. Jacob Meyers Park to Orange Blossom Rd. Bridge (Figure 2); and
4. Orange Blossom Rd. Bridge to Knights Ferry (Figure 3).

Floodplain inundation is initiated at 1,250 cfs in the Ripon to Jacob Meyers Park and in the Orange Blossom Rd. Bridge to Knights Ferry reaches. The Ripon to Jacob Meyers Park reach has substantially more available floodplain. The relationship between flow and inundated floodplain area, together with historical stream gage data, can be used to calculate the number of acre days of inundated floodplain for an appropriate period of each year, such as February 1st to May 31st. This metric can be used in a regression analysis with juvenile survival estimates based on rotary screw trap data to understand how inundated floodplain area affects juvenile survival and growth (Table 2; USFWS, In Prep; CFS 2012).

- **Primary Outcome:** Inundate floodplain rearing habitat for juvenile Chinook salmon to increase productivity, growth, and survival.
    - Implicit = increase juvenile Chinook salmon growth and survival
    - Alternate statement of outcome = Enhance juvenile Chinook salmon size at emigration to improve survival through the lower Stanislaus River, San Joaquin River, and Delta.
- **Secondary Outcomes:**
    - Implicit = Improve temperatures for juvenile rearing (≤ 16° C) from March-April and smolt migration (≤ 18° C) from April-May
    - Implicit = Improve riparian habitat and cottonwood recruitment
- **Action:**
    - Inundate at least 300 acres of floodplain habitat for a minimum of 14 consecutive days during February 1st to May 31st in the following reaches:
        - Ripon to Jacob Meyers Park
        - Jacob Meyers Park to Orange Blossom Rd. Bridge, and

        - Orange Blossom Rd. Bridge to Knights Ferry.
    - Spring pulse flows of at least 3,000 cfs during Dry, Below Normal, Above Normal, and Wet years will need to be maintained for a minimum of 14 consecutive days each year in 90% of years.
- **Approach:**
    - Provide an additional 83,303 acre feet of water for flows that will inundate floodplain habitat available to juvenile salmon in the Stanislaus River for a variety of water year types.
    - To inundate at least 300 acres of floodplain rearing habitat in the lower Stanislaus River, spring pulse flows will need to be at least 3,000 cfs and will need to be maintained for
        - a minimum of 14 consecutive days
        - from February 1st to May 31st .
- **Background:**

Floodplain rearing and off-channel habitat are important because they increase both the growth and survival of juvenile salmonids (Sommer et. al. 2001). The frequency and timing of flows during the juvenile rearing period (January to May) are attenuated in the San Joaquin River Basin. The amount of juvenile Chinook salmon floodplain rearing habitat is dependent upon the San Joaquin Basin Water Year Type and instream flow releases downstream of Goodwin Dam in the Stanislaus River. Floodplains provide food resources, which contribute to faster growth rates in floodplain reared fish than experienced by fish rearing in the main river channel. In general, the food productivity on floodplains tends to include high levels of phytoplankton and zooplankton, invertebrate drift, and allochthonous input. Increasing the amount of floodplain habitat available to juvenile salmon in the Stanislaus River at a variety of flow conditions could increase the overall size of juveniles and lead to higher survival. Additionally, the flow reductions in late spring and early summer are too rapid to allow recruitment of large riparian trees, such as Fremont cottonwoods. Consequently, within 10 to 20 years, as existing trees senesce and fall, there will be no younger riparian trees to replace them, resulting in less riparian shading, higher in-stream temperatures, less food production from allochthonous sources, and less large woody debris (LWD) for nutrients and channel complexity (NMFS 2009).

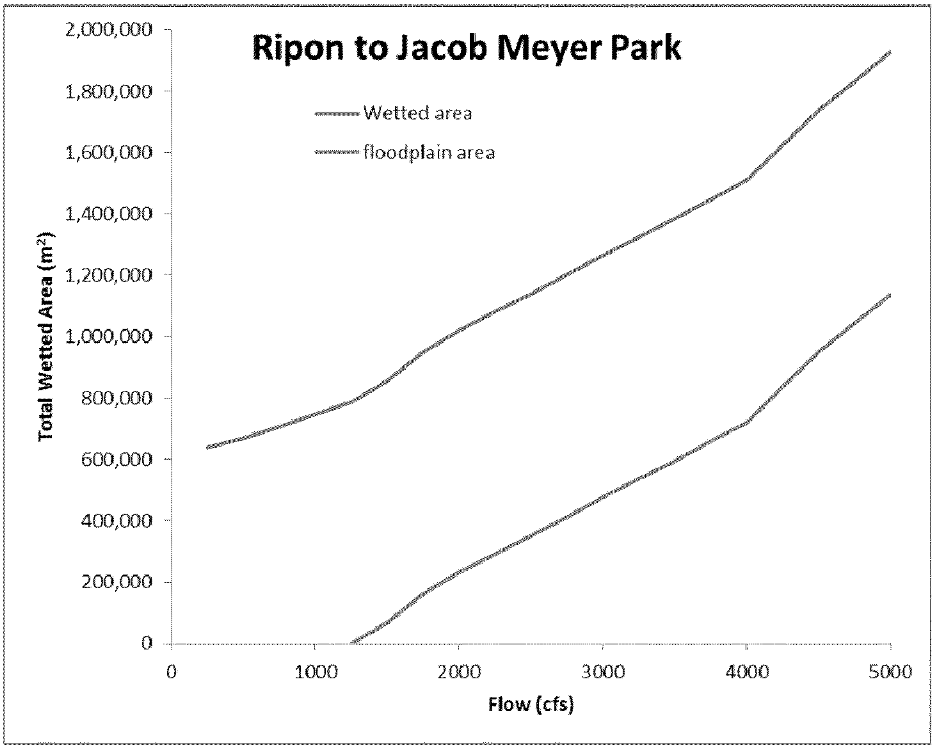

Figure 1. Floodplain (total wetted area in square meters),.versus flow (in cubic feet per second) relationship for the Ripon (RKM 25.8) to Jacob Meyer Park (RKM 53.8) reach in the Stanislaus River, CA.

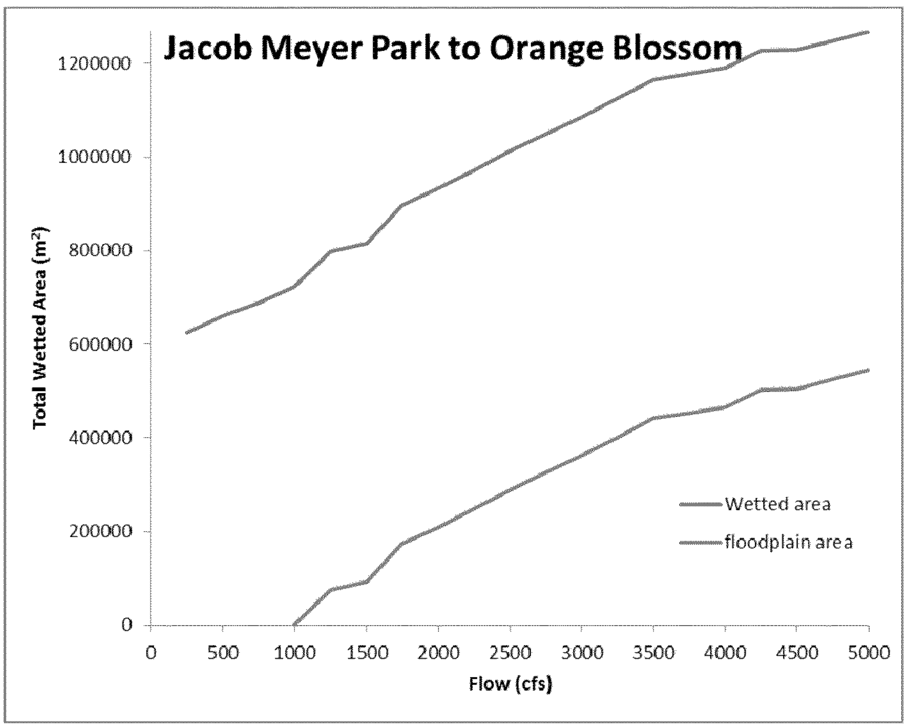

Figure 2. Floodplain (total wetted area in square meters) versus flow (in cubic feet per second) relationship for the Jacob Meyer Park (RKM 53.8) to Orange Blossom Rd. Bridge (RKM 75.5) reach in the Stanislaus River, CA.

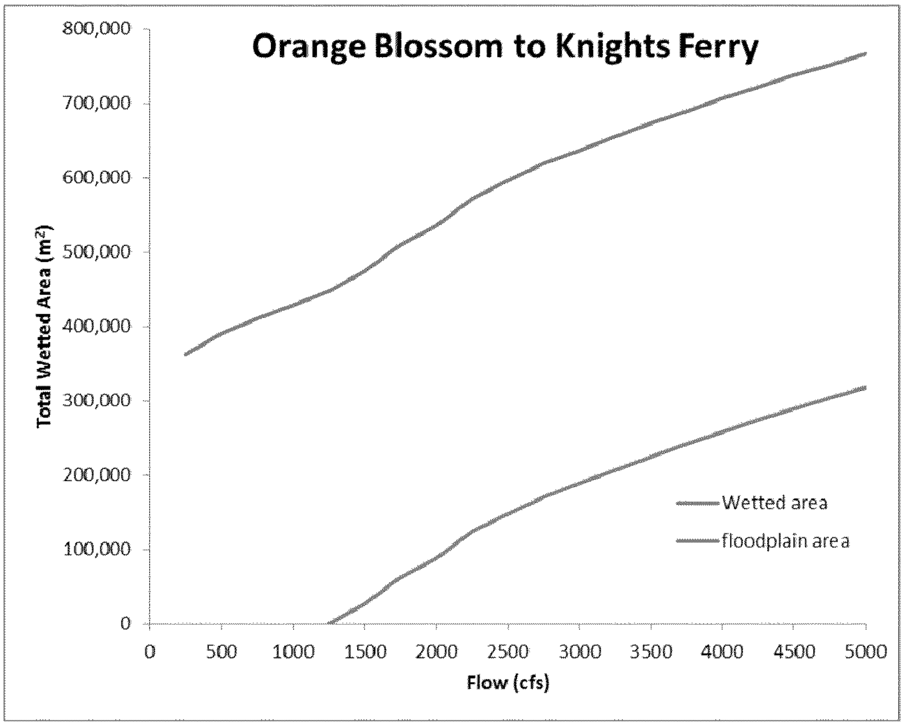

Figure 3. Floodplain (total wetted area in square meters) versus flow (in cubic feet per second) relationship for the Orange Blossom Rd. Bridge (RKM 75.5) to Knights Ferry (RKM 86.9) reach in the Stanislaus River, CA.

TABLE 1
RELATIONSHIP BETWEEN DISCHARGE (STEPPED IN 250 CFS INCREMENTS) AND INUNDATED ACRES FOR THE STANISLAUS RIVER, WITH ACREAGE VALUES AVERAGE BETWEEN THE RIPON TO JACOB MEYERS PARK REACH; THE JACOB MEYERS PARK TO ORANGE BLOSSOM RD. BRIDGE REACH; AND THE ORANGE BLOSSOM RD. BRIDGE TO KNIGHTS FERRY REACH.

Discharge (cfs)	Wetted Acres
1000	0
1250	14
1500	57
1750	98
2000	135
2250	168
2500	199
2750	227
3000	254
3250	281
3500	308
3750	335
4000	364
4250	393
4500	425
4750	460
5000	497

TABLE 2
MAXIMUM WETTED ACRES OF 2 WEEK DURATION BETWEEN FEBRUARY - MAY FOR EACH YEAR FROM 1995 TO 2012 AT 1) OBSERVED GOODWIN DAM FLOW, 2) GOODWIN DAM FULL NATURAL FLOW (FNF), AND 3) AFRP (2005) CHINOOK DOUBLING FLOW RECOMMENDATIONS AND THE ESTIMATED TOTAL NUMBER OF JUVENILE CHINOOK SALMON PASSING THE CASWELL ROTARY SCREW TRAP IN THE STANISLAUS RIVER, CA.

YEAR	SJ WYI	WETTED ACRES AT OBSERVED GOODWIN FLOW	WETTED ACRES AT GOODWIN FNF	WETTED ACRES AT AFRP 2005 CHINOOK DOUBLING FLOWS	ESTIMATED TOTAL NUMBER OF JUVENILE CHINOOK SALMON
1995	W	10	497	471	
1996	W	305	393	471	70,908(±7,791)*
1997	W	497	409	471	92,703(±20,142)*
1998	W	303	497	471	1,085,158(±171,487)
1999	A	309	497	327	1,478,890(±229,171)
2000	A	227	336	327	2,049,722(±271,452)
2001	D	57	248	128	166,741(±20,193)
2002	D	0	289	128	91,010(±12,817)
2003	B	0	462	226	144,474(±17,690)
2004	D	0	237	128	406,541(±66,995)
2005	W	57	497	471	256,652(±33,650)
2006	W	497	497	471	228,983(±98,701)*
2007	C	57	164	46	75,596(±44,561)
2008	C	27	251	46	16,377(±7,977)
2009	B	3	444	226	7,953(±5,044)
2010	A	0	261	327	219,919(±244,758)
2011	W	202	497	471	328,541(±360,786)
2012	D	59	298	128	
	average	*145*	*376*	*296*	
	min	*0*	*164*	*46*	
	max	*497*	*497*	*471*	
	median	*57*	*401*	*327*	
	% of Actual	***100.0***	***259.6***	***204.4***	

*Trap only operated during part of the outmigration period due to high water conditions.

SEP Evaluation of the Conservation Measure

Evaluation Team

Lead Author:	Rene Henery (Trout Unlimited)
Support Authors:	Andrea Fuller (FISHBIO) and John Wooster (NMFS)
Reviewer:	Not peer reviewed.
Workshop Participants:	John Wooster (NOAA), Julie Zimmerman (USFWS), Ali Weber-Stover (TBI), and Michael Martin (Merced River Cons. Comm).

Date of Evaluation Workshop; time CM was evaluated

Conservation measure, scale, and which outcomes should apply were reviewed by two sub-groups of the evaluation team as indicated above on April 10, 2013. Following the workshop, Rene Henery took the lead in drafting the evaluation with input from Andrea Fuller (FISHBIO).

Modifications to the Conservation Measure

The following modification was made to the action:

Spring pulse flows of ~~at least 3,000~~ 3,500 cfs ~~during Dry, Below Normal, Above Normal, and Wet years~~ will need to be maintained for a minimum of 14 consecutive days ~~each year in 90% of years~~ during all but Critically Dry years, which we assume will occur only 20% of the time.

The following modifications were made to the approach:

~~Provide an additional 83,303 acre feet of water for flows that will inundate floodplain habitat available to juvenile salmon in the Stanislaus River for a variety of water year types.~~

To inundate ~~at least~~ 300 acres of ~~floodplain~~ off-channel rearing habitat in the lower Stanislaus River, spring pulse flows will need to be ~~at least 3,000~~ 3,500 cfs during all but Critically Dry water years and will need to be maintained for:

- a minimum of 14 consecutive days in 80 percent of years
- a minimum of 21 consecutive days in 40 percent of years
- a minimum of 28 consecutive days in wettest 20 percent of years
- from February 1st to May 31st

Clarifying Assumptions

- The 300 acres of off-channel habitat represents the difference between an estimate of total wetted acres at 1,000 cfs and an estimate of total wetted acres at 3,500 cfs.

- Inundated area includes a range of off-channel habitat including side channels and backwaters, and does not necessarily include traditional "floodplains" where the alluvial fan surface becomes inundated.
- Depths and velocities in inundated areas may not be suitable for juvenile Chinook salmon rearing.
- Increase in fish growth from Ramon's data is correlated with water year type and assumed to be from factors associated with off channel inundation (e.g. increased prey abundance).
- These inundated areas are vegetated.
- Reconnection and restoration of connectivity to areas that already have food production
- Longer than 14 days necessary for cottonwood recruitment
- Longer than 14 days and perhaps 21-28 days necessary for aquatic origin secondary production.
- The project is adequately scaled that the benefits will occur. [Note from reviewer: *Shouldn't this be a question considered as part of the scoring rather than simply assuming that "benefits" will occur?*]
- Off-channel habitat is distributed throughout the system, not one 300 acre parcel

Scale of Action: Medium

Rationale:
The CM description and background lacked specificity in a number of areas critical for determining the scale of the action, including habitat suitability of inundated areas, habitat need relative to AFRP fish production targets, terrestrial and aquatic productivity potential relative to habitat type for inundated areas, potential for increased predation risk as a function of pit reconnection, and relative potential for native vs. invasive vegetation colonization. As a result, there was significant discrepancy in the scale attributed by the two subgroups that worked on the evaluation independently. Ultimately, the scale of "Medium" was selected. Specifically, it was determined that the CM entailed small acreage inundated with moderate duration (14-28 days) and significant frequency (80% of years), and the change is moderate relative to existing conditions based on the following factors:

- Despite a doubling of inundated area by the proposed CM relative to existing conditions (145 acres average, see Table 2 in CM description), the sum of the fragmented, inundated areas is tiny in comparison to other Central Valley floodplains such as the 59,000 acre Yolo Bypass (Opperman et al. 2010) and the 46,000 acre Cosumnes River Preserve.
- The 300 acres of floodplain habitat is distributed over approximately 40 miles of river as opposed to occurring in one or a few large areas.
- Habitat suitability of inundated areas has not been evaluated. Suitable acreage will be less than the estimated 300 acres of inundated area.
- Duration relative to beneficial processes – veg recruitment, food production, fish growth

- Duration may be underestimated in that only the minimum intervals were considered during the evaluation of this CM.
- Frequency may be underestimated in that it was assumed that in all but critically dry years inundation would occur a minimum of once and information to assess potential benefits of multiple inundation events per year were not presented.
- The action will occur in all but Critically Dry years and it is assumed that this corresponds to the action occurring in 80% of years.
- [Note from reviewer – for bullets below: Not sure these belong here. Move to outcomes?]
- The bulk of the habitat that will be inundated is already vegetated. Recent research from CV floodplain indicates that solar exposure in open areas, combined with longer residence times is critical for in-situ primary and secondary production on inundated floodplains.
- Related to the point above, prey abundance benefits from terrestrial inputs are more closely tied with frequency of inundation than with duration. However, frequency of inundation for different water year types has not been evaluated.
- While the literature indicates improved growth for juvenile fish rearing on floodplain in other systems, the larger fish size at migration in the Stanislaus River that is observed in high water years is assumed to be attributed solely to increased floodplain area. There is no direct evidence of this.
- There is no evidence from this system that correlates increased size at migration with improved survival. This is merely assumed based on evidence from other systems.
- Despite assumed positive outcomes for riparian vegetation recruitment, there is no discussion or justification for whether or why increased inundation would favor native vs. invasive riparian vegetation colonization.
- Despite assumed lower predation rates in inundated off-channel habitats, and potential for reduced predation as a function of larger size, juvenile outmigrants are still required to navigate through the same zones of increased predation, as well as through newly connected pits where predation potential is poorly understood but presumed high. There is therefore a great deal of uncertainty about the relative extent to which the CM will lower predation risk or rates.

Notes taken During Evaluation Workshop

Group #1

- CM Scale: Large

Group #2

- CM Scale: Medium, given limitations of system.

Evaluation Summary

Potential Positive Ecological Outcome(s)

Outcome P1-A: Increased Habitat Extent

See Outcome P3

Outcome P1-B: Increased Habitat Connectivity

Clarifying Assumptions:

- CM is not a landscape level effect

Scientific Justification:

- **Magnitude #3:** Critically dry year would have impact on the population but would be better conditions than present for most years. Deals with multiple patches of habitat, but these patches are small and of undescribed quality relative to habitat conditions beneficial for juvenile rearing.

- **Certainty #2 (3):** The sequence of water years types is unknown and multiple critically dry years in a row (as may be increasingly likely under climate change scenarios) would reduce the population level benefit of the CM. Understanding is high but outcome is highly variable. Area of inundation is known but the specific benefit and habitat suitability/quality is unknown.

Outcome P3: Additional rearing habitat

Clarifying Assumptions:

- CM is not a landscape level effect

Scientific Justification:

- **Magnitude #3:** Can be sustained because we are making giving access to off channel habitat during dry years. Critically dry year would have impact on the population but would be better conditions than present for most years. Deals with multiple patches of habitat

- **Certainty #2 (3):** Success is driven by natural fluctuations in water year. The sequence of water years types is unknown and multiple critically dry years in a row (as may be increasingly likely under climate change scenarios) would reduce the population level benefit of the CM. Understanding is high but outcome is highly variable. Area of inundation is known but the specific benefit and habitat suitability/quality is unknown.

Outcome P7: Increased establishment of woody riparian vegetation providing shaded channel habitat, increased channel margin complexity, and export of large woody debris (LWD)

Clarifying Assumptions:

- It is highly likely that CM will produce better vegetative cover though greater frequency of inundation.
- Need additional information about recession rates in order to increase certainty score where specific vegetation types are concerned.

Scientific Justification:

- **Magnitude #2:** CM will likely provide more food, large woody debris, habitat shading and complexity. However, there will be only a limited spatial habitat effect of adding woody riparian habitat. The primary mechanism for recruitment is seed dispersal to perched areas that currently get no access to water. Other areas, however are already vegetated
- **Certainty #3:** Inundated area may also change vegetation, i.e. cottonwoods may not survive. Certain benefit that vegetation will result. The direct benefits are less certain in connection in population and fish population.

Outcome P10: Increased delivery of readily-suspendable sediments providing increased turbidity downstream, improved habitat conditions, and greater feeding success, and reduced predation

Clarifying Assumptions:

- None

Scientific Justification:

- **Magnitude #2:** Increased turbidity (*?*) – not due to reservoir releases. Cite RST turbidity data. Greater feeding success [*?*] Turbidity and predation [*2003 fry pulse eval. Others?*] Turbidity more likely to help fry than smolts. Need 5-8 CFS to increase turbidity (Kondolf 2001) [*Note from reviewer: This is not correct. perhaps this referring to sediment mobilization at 5,000-8,000 cfs?]*
- **Certainty #2:** Understanding is high that increased inundation due primarily to reservoir releases and in the absence of substantial local run-off is not likely to result in significant increases in turbidity [*Need citation*].

Outcome P11: Contributes to conditions with water temperatures appropriate for Salmonid migration, spawning, incubation, and rearing

Clarifying Assumptions:

- Will only occur in 80% of years, not critically dry years

Scientific Justification:

- **Magnitude #2:** Water temperatures for juvenile Chinook salmon rearing and outmigration may decrease during the prescribed inundation intervals because due to increased flows. Temperatures in off-channel habitats with longer residence times may be warmer than in-channel, but expected differences in temperature between existing conditions and off-channel habitats is unknown as is expected usage of off-channel habitats therefore the magnitude is uncertain. Temperature effects will occur only over limited time periods of 14-28 days.

- **Certainty #3:** There are potential negative consequences associated with increased cold water in this system. The extent of temperature improvements are not consistent but instead largely constrained and regulated by variability in external conditions

Outcome P12: Increased production and local availability of aquatic food resources (POM, phytoplankton, zooplankton, small fish, etc)

Clarifying Assumptions:

- Floodplain can provide significantly increased production of aquatic invertebrates during longer residence time inundations, in cases where there is adequate solar exposure to promote primary productivity.

- Floodplain inundation can also provide increased terrestrial invertebrate prey. However, this benefit occurs relatively close to the onset of inundation and diminishes subsequently. As a function of this, it is more closely tied to frequency of inundation than duration.

- In addition to increased prey abundance, inundated habitat can also provide increased access to food

- The areas being reconnected include several that are already pooling water, with food resources.

- There is no direct correlation between inundation and productivity as a result of the range of other factors that affect the type and extent of productivity.

Scientific Justification:

- **Magnitude #2:** Improvements or increase to in situ aquatic secondary production will be limited because only a small portion of the inundated area will consist of already wetted areas, or open areas with long residence times where significant primary and secondary productivity is likely.

- **Certainty #3:** There is a high likelihood that areas with additional food resources will be inundated and that juvenile fish will have access to these.

Outcome P13: Increased production of terrestrial invertebrates put into the aquatic ecosystem for rearing covered fish

Clarifying Assumptions:

- Existing habitat to be inundated is often heavily vegetated

Scientific Justification:

- **Magnitude #2:** Increased introduction of terrestrial invertebrates would occur during initial inundation only. Frequency of inundation is prescribed by the CM to occur at least once per year in 80% of years, but it is unknown how frequently multiple inundation events may be expected to occur. In the case of terrestrial invertebrates, the frequency of inundation is of critical importance to understanding the potential for input of terrestrial invertebrates as a food source for juvenile Chinook salmon. How increased introduction of terrestrial invertebrates would affect the Chinook salmon population is uncertain as food supply does not appear to be a key limiting factor.

- **Certainty #2:** In the case of terrestrial invertebrates, the frequency of inundation is of critical importance to understanding the potential for input of terrestrial invertebrates as a food source for juvenile Chinook salmon. How increased introduction of terrestrial invertebrates would affect the Chinook salmon population is uncertain as food supply does not appear to be a key limiting factor.

Outcome P14: Food resources produced on the restored habitat will be exported and contribute to food availability in downstream aquatic areas. (Note: food resources could include organic carbon, phytoplankton, zooplankton, and other organisms)

Clarifying Assumptions:

- Assumes that 300 acres of off-channel habitat results in increase in fish size due to increased prey availability and access.

Scientific Justification:

- **Magnitude #2:** Only a fraction/ part of the juvenile fish population will be affected by export

- **Certainty #3:** Existing prey density in the Stanislaus River and how this relates to prey density in systems where export benefits have been measured is not well understood.

Outcome P17: Reduced predation mortality (i.e. due to striped bass, black bass, and other non-native predatory species)

Clarifying Assumptions:

- CM involves doubling existing acreage of off-channel habitat
- Some off-channel habitat includes shallow areas with good cover which would be favorable to juveniles and that predators will be significantly less likely to occupy.
- Assumes that 300 acres result in significant increase in fish size.

Scientific Justification:

- **Magnitude #2:** Predation is presumed to be a limiting factor for juvenile Chinook salmon in the Stanislaus River based on losses between the rotary screw traps at Oakdale and Caswell (SRFG 2004); from radio tracking studies of salmon smolts conducted in 1998, 1999, 2012; and electrofishing conducted in 1999. A study conducted in 2012 indicates that the majority of juvenile Chinook salmon losses in the lower Tuolumne River between Waterford and Grayson could be explained by predation based on estimated predator abundance and predation rates (TID/MID 2013). Refuge from predators in off-channel habitat has the potential to reduce predation mortality during rearing, however juvenile Chinook salmon would still be exposed to predators during migration so it is unclear to what extent predation mortality would be reduced or simply delayed. Additionally, an unknown, but due to the incised nature of the channel, presumably small, portion of the 300 acres is expected to have shallow, low velocity floodplain habitats representative of those observed elsewhere in the Central Valley to be benefical to rearing juvenile salmon. There is limited spatial area that could have reduced predation.

- **Certainty #2:** However predator abundance, distribution, and predation rates relative to flow and habitat have not been evaluated in the Stanislaus River.

Outcome P20: Increase juvenile Chinook salmon growth rate

Clarifying Assumptions:

Scientific Justification:

- **Magnitude #2-3:** The mechanisms that may result in increased growth by this CM are increased rearing temperatures and food availability in off-channel habitats relative to in-channel habitats. Increased growth rates have been documented in large floodplains relative to in-river, however this CM would inundate small, fragmented areas of unknown quality (i.e., depth and velocity). Growth rates have not been estimated in the Stanislaus River to begin to determine how growth rates may be affected by this CM. While fish size at migration in the San Joaquin Basin (measured at Mossdale) is greater in wet years, outmigration also extends later in these years so the difference in size may be due to more time spent in-river before migration rather than increased growth rate. Growth rates of 0.38 mm/day and 0.33 mm/day have been reported for fish rearing in the American River and Sacramento River, respectively (Castleberry et al. 1991, Castleberry et al. 1993). Rates reported for the Delta were higher, ranging from 0.53 mm/d to 0.86 mm/d. [Note from reviewer: *Need to look at original docs. This is as cited in Myrick and Cech 2001. What were the temps and how do they compare to Stan?*] Minimum of 14 days is short duration. Outcome dependent on when the event occurs as this influences the number of individuals that have the potential to be affected. The later in the season, the smaller number of individuals potentially affected. Timing also important due to influence of ambient temperatures on water temperatures.

- **Certainty #2:** Increased growth rates have been documented in large floodplains relative to in-river, however this CM would inundate small, fragmented areas of unknown quality (i.e., depth and velocity) so the same results should not be expected. Lack of understanding of existing growth rates; temperatures in off-channel areas and how they would vary with season and meteorology; and the overall quality of the off-channel areas. Lack of specificity in terms of timing.

Outcome P21: Increasing temporal distribution of freshwater lifestages [Note from reviewer: *Revised for consideration*]

Scientific Justification:

- **Magnitude #2-3:** [Note from reviewer: *This was not scored by the groups and have thrown out some ramblings in an attempt to assemble logic and foster discussion among the team.*] During wet water years the proportion of juvenile Chinook salmon smolt outmigration occurring in late May and into June was higher than in other water year types (Fuller and others 2012). However, the timing, duration, and magnitude of flow, and the influence of other factors on migration timing must be considered in determining whether the temporal distribution of outmigration would be expected to increase by implementing this CM. Extension of the temporal distribution of migration was greatest in 2006 (W), 1999 (AN), and 1998 (W), and during each of these years flows at Ripon averaged 3,000 –4,000 cfs, and generally exceeded 2,000 cfs for periods of 40-90 days between February 1st and May 31st. [Note from reviewer: *Need to address 2005. This was a wet water year, but coming off of 4 BN and D years flows were low (avg: 365 cfs, range: 269-878) during Feb-Apr and increased to ~1,500 cfs during May. Fish migration occurred later in this year even though flows were not representative of what would be expected in a wet year. Is this an indication that migrating timing is affected more by water year type (i.e., meteorology) than by flows or is this the combined result of meteorology and fish not wanting to migrate earlier under low flows?*]While migration was extended in 1999, flows of similar magnitude and timing in 2000 (AN), did not result in extension of the temporal distribution of smolt outmigration. However the duration of the flow events differed between 1999 and 2000. During 2000 the high flow period extended 25 days from mid-February to mid-March whereas the duration was 40 days during February 1st through mid-March of 1999. It is unclear whether the extended migration timing in 1999 relative to 2000 was due to differences in the durations of flow events, differences in growth rates, differences in water temperature or some combination of these and possibly other factors.

Relative to existing conditions this conservation measure would not be expected to increase the temporal distribution of outmigration in wet years and some above normal years since extended distribution of outmigration already generally occurs under existing conditions. No action would be taken in critically dry years. Over the past 20 years (water years 1993-2012), there were 8 wet years and 3 critically dry years, leaving 9 years of other water year types in which the CM would be expected to have the potential to increase the temporal distribution of outmigration. Of these 9 years, the CM would be implemented in 80%, or 8 years out of 20 years. This means that relative to existing conditions, the temporal distribution of outmigration might be extended in up to 40% of years. However this is based on a minimum duration of only 14 consecutive days, whereas the intervals ranged from 40-90 days in years when outmigration was observed to be extended.

t is not clear if leaving later would result in a population level effect as the ultimate survival of these outmigrants is uncertain. The outcome is highly dependent upon other external factors including water temperatures which are affected by variable meteorology and survival through the Delta. Delta conditions are likely to be less favorable leading to lower survival later in the season so there may be no population level benefit to extending the temporal distribution of migration.

- **Certainty #3:** Understanding is high that the temporal distribution of juvenile outmigration is generally extended during wet years and that high flow events averaging 3,000-4,000 cfs for 40-90 days during wet and above normal years extended the temporal distribution of outmigration from the Stanislaus River.

Potential Negative Ecological Outcome(s)

Outcome N2: Establishment of undesirable species (such as Arundo or other invasive species) that will alter habitat conditions

Clarifying Assumptions:

- Will occur in 80% of years, not critically dry years

Scientific Justification:

- **Magnitude #2:** Significant potential and likelihood for expansion of Arundo based on existing distribution and abundance of Arundo in the system. A significant portion of the existing habitat is already vegetated, however, limiting the areas where potential expansion of invasive vegetation could occur.

- **Certainty #3:** There is a high likelihood that increased inundation will result in increased vegetation colonization in those areas where inundation does not currently occur and riparian vegetation is not yet established.

Data Gaps, Key Uncertainties, New Ideas, and Suggestions for Future Planning

Data Needs:

- Temperature data/ model that correlates flow and in river temperature with external temperature.
- Floodplain area broken down by physical attributes tied with habitat suitability including depth, velocity, and cover type and extent
- Distribution of vegetation type (invasive vs. native) relative to exposed areas that will be inundated under CM
- Additional inundation information including a) frequency of inundation events in different categories of duration for different water year types, b) hydrologic recession rate and period for different inundation events.

Key Uncertainties and Research Needs:

- **Floodplain habitat needs to achieve AFRP Salmon targets** – Currently, floodplain habitat improvements are compared with heavily impacted existing conditions. In order to more effectively gage the magnitude and potential effect of floodplain restoration, floodplain habitat should be placed in the context of targets necessary to achieve the AFRP goals. These targets could be established/ estimated through a range of methods including: a) as a function of historic floodplain habitat available, scaled relative to flow regime, b) as a function of territory needs, in the context of prey density and habitat structure (Cramer and Ackerman 2009) for juvenile progeny that would result from adult returns equivalent to AFRP targets, or c) based on the ratio of historic habitat to historic production scaled to AFRP targets.
- **Predator density and habitat relationships** – Predation rates and predator densities in different habitat types within the system are not well understood, making it difficult to assess effects of the proposed action on predation rates. Information on predation rates relative to temperature would also be informative in this regard. Within the range of habitat types, predator density and predation potential in pits that would become connected under proposed action would be among the priority areas.
- **Aquatic and terrestrial productivity** - Need additional information pertaining to inundation event characteristics (duration, frequency, timing, depth) in different water year types and quantify and quality of aquatic primary and secondary productivity, as well as potential for increased terrestrial prey availability, as a function of habitat type. This would support a more thorough understanding of the potential mechanisms for the anticipated improved growth, the carrying capacity for the expanded habitat in terms of that improved growth potential, as well as the potential for export of prey to downstream habitats .

Important New Ideas or Understandings:

N/A

Potential CM Re-configurations to Increase Worth /Decrease for Implementation

N/A

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Appendix A: Summary Tables Organized by Outcome- (*Not complete*)

TABLE A1
POSITIVE OUTCOMES

Standarized Outcomes for Stanislaus River SEP		Scoring	
Standard Outcome Code	Outcome (brief descriptor)	Magnitude	Certainty
Habitat - Spatial Extent			
P1	Connectivity of habitat	3	3
P3	Rearing	3	2
P4	Expand Spatial Distribution	3	2
Habitat Quality			
P7	Shaded Channels /Channel Margin/LWD	2	3
P8	Emergent Vegetation	2	3
P10	Suspended Sediments	2	2
P11	Water Temperature	2	3
Food			
P12	Increased Local Aquatic Primary and Secondary Production	2	3
P13	Increased Terrestrial Invertebrates	3	3
P14	Food Export	2	3
Mortality			
P17	Reduced Predation	2	2
Size			
P20	Increase juvenile chinook salmon size at emigration	-	-
Life History			
P21	Increase life history diversity (or diversity of outmigration)	-	-

TABLE A2
NEGATIVE OUTCOMES

Standarized Outcomes for Stanislaus River SEP		Scoring	
Standard Outcome Code	Outcome (brief descriptor)	Magnitude	Certainty
Habitat Quality			
N2	Establishment of Invasive Species	2	3
Mortality			
N4	Increased Entrainment	-	-
Contaminents			
N5	Mercury Methylation	-	-

		Worth		Risk		Worth		Risk	
Standard Outcome Code	**Outcome (brief descriptor)**	**Grade**	**Numeric**	**Grade**	**Numeric**	**Grade**	**Numeric**	**Grade**	**Numeric**
Habitat - Spatial Extent									
P1	Connectivity of habitat	High	3			Med	2		
P3	Rearing	Med	2			Med	2		
P4	Expand Spatial Distribution	Med	2			Med	2		
Habitat Quality									
P7	Shaded Channels /Channel Margin/LWD	Med	2			Med	2		
P8	Emergent Vegetation	Med	2			Med	2		
P10	Suspended Sediments	Med	2			Med	2		
P11	Water Temperature	Med	2			Med	2		
N2	Establishment of Invasive Species			Med	2			Med	2
Food									
P12	Increased Local Aquatic Primary and Secondary Production	Med	2			Med	2		
P13	Increased Terrestrial Invertebrates	High	3			High	3		
P14	Food Export	Med	2			Med	2		
Mortality									
P17	Reduced Predation	Med	2			Med	2		
N4	Increased Entrainment				---				---
Contaminents									
N5	Mercury Methylation				---				---
Size									
P20	Increase juvenile chinook salmon size at emigration		---				---		
Life History									
P21	Increase life history diversity (or diversity of outmigration)		---				---		

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CM 07: CREATE FLOODPLAIN AND SIDE CHANNEL REARING HABITAT

Scientific Evaluation Process (SEP) Worksheet

Table of Contents

Conservation Measure Description

Recent studies have shown that available rearing habitat within the typical range of New Melones operations (from 250 cfs to 1,500 cfs) is limited in the lower Stanislaus River (USBR 2012).

Providing floodplain and side channel habitat for Chinook salmon in the Stanislaus River has been identified as a high priority action for the Anadromous Fish Restoration Program (USFWS 2001). Floodplains provide food resources, which contribute to faster growth rates than fish rearing in the main river channel.

Many existing side channel areas are presently disconnected from the river during time periods critical for salmon rearing because of geomorphic changes to the river and current water operations. Increasing the amount of floodplain and side channel habitat available to juvenile salmon in the Stanislaus River at a variety of lower-flow conditions could increase the overall size of juveniles and lead to higher survival. Therefore, there is a need to create additional side channel and floodplain habitat that will inundate more frequently through non-flow actions. This conservation measure is within the lower Stanislaus River between Goodwin Dam (RM 58.4) and the river's confluence with the San Joaquin River (RM 0), and includes construction of floodplain and side channel habitats that are frequently inundated (i.e. at relatively-low discharge levels). Because change sin flow are assumed to not be a part of this CM, the main mode of implementation will be excavation (lowering) of floodplain and side channel areas.

- **Primary Outcome:** Restore floodplain and side channel habitat for juvenile Chinook salmon rearing to increase productivity, growth, and survival.
  - Implicit = increase juvenile Chinook salmon growth and survival
  - Alternate statement of outcome = increase juvenile Chinook salmon size at emigration to improve survival through the lower Stanislaus River, San Joaquin River, and Delta.
- **Secondary Outcomes:**
  - Implicit = Reduce predation on juvenile Chinook salmon by isolating ponded sections of the river and creating alluvial braided channels.
  - Implicit = Improve riparian habitat and cottonwood recruitment.
- **Action:**
  - Restore at least 100 acres of floodplain and side channel habitat in the Ripon to Knights Ferry reaches that will inundate more frequently (e.g., at flows ranging from 250 to 1,500 cfs).
- **Approach:**
  - Restore floodplain and side channel habitat that will inundate more-frequently at a variety of lower flow conditions.
  - Side channels will be designed to inundate at flows ranging from 250 to 1500 cfs, and it is assumed this will occur annually.
  - Floodplain inundation is initiated at 1,250 cfs in the Ripon to Jacob Meyers and in the Orange Blossom to Knights Ferry reaches.
  - Historic side channels and floodplain in these reaches have been disconnected from the channel and should be reclaimed to make them accessible to rearing salmonids. A GIS data set depicting inundation at a variety of flows (250 to 2000 cfs) can be used to prioritize areas for restoring floodplain habitat.
  - Gravel processing will be performed to sort materials into several size ranges including: 1) cobbles and larger rocks for reuse on the mid-channel floodplain; 2) gravels within a preferred particle size distribution suitable for spawning purposes for use in mainstem spawning riffles; and 3) fine material and excess

fine gravels to be used as onsite fill and for revegetation outside the floodplain footprint.

- Material will be excavated from historic side channels, screened, and sorted on-site. Appropriate sized rearing material would then be placed back in the channels to encourage favorable hydraulic conditions that will result in increased connectivity of the river with the new habitat features given existing flow conditions.
- Large cobble would be used as a base layer in the side channels and at the toe of each bank to provide increased stability during high flow events and habitat heterogeneity throughout the site.

- **Background:**

In 2010, the U.S. Fish and Wildlife Service implemented an Instream Flow Incremental Methodology (IFIM) hydraulic and habitat modeling study for fall run Chinook salmon. In 2012, a model was developed to estimate the floodplain area versus flow in the Stanislaus River. Floodplain rearing habitat was computed for flows up to 5,000 cfs. Additionally, a two dimensional hydraulic model was developed to quantify the relationship between floodplain area and flow ranging from 250 to 5,000 cfs for the following four reaches of the Stanislaus River: 1) confluence with San Joaquin River to Ripon; 2) Ripon to Jacob Meyers Park; 3) Jacob Meyers Park to Orange Blossom Rd. Bridge; and 4) Orange Blossom Rd. Bridge to Knights Ferry.

In their comprehensive assessment, the California Department of Water Resources (DWR) (DWR 1994) identified nine potential salmon habitat restoration sites in the Stanislaus River and recommendations included replacing gravel, isolating predator habitat, and restoring existing side channel habitat. Recommendations of the San Joaquin River Management Plan (1995) also suggest improving gravel quality to increase survival of salmon eggs and enhance the channel and riparian corridor of the Stanislaus River. Floodplain rearing and side channel habitat are important because they increase both the growth and survival of juvenile salmonids (Sommer et. al. 2001). The frequency and timing of flows during the juvenile rearing period (January to June) are attenuated in the San Joaquin River Basin. The amount of juvenile Chinook salmon floodplain rearing habitat is dependent upon the San Joaquin Basin Water Year Type and instream flow releases downstream of Goodwin Dam in the Stanislaus River. Floodplains provide food resources, which contribute to faster growth rates than fish rearing in the main river channel. In general, the food productivity in floodplains tend to have high levels of phytoplankton and zooplankton, invertebrate drift, and allochthonous input. Increasing the amount of floodplain habitat available to juvenile salmon in the Stanislaus River at a variety of flow conditions could increase the overall size of juveniles and lead to higher survival.

To date, the AFRP has implemented three floodplain restoration projects in the Stanislaus River (i.e. Lovers Leap, Lancaster Rd., and Honolulu Bar) and environmental scoping documents are being developed for two additional projects (i.e. Knights Ferry and Buttonbush). The following are descriptions of these three examples:

Lovers Leap Restoration Project (KDH 2008)

The Lover's Leap Restoration Project was intended to replenish spawning gravel at existing and new restoration sites in the lower Stanislaus River near Lover's Leap and to restore riverbed topography. The overall objective was to increase and improve Chinook salmon (*Oncorhynchus tshawytscha*) and Central Valley steelhead (*O. mykiss*) spawning and rearing habitat by adding cleaned spawning sized gravels to degraded areas within the 25.5 mile salmonid spawning reach. Project outcomes will contribute to the Central Valley Project Improvement Act (CVPIA) goal of at least doubling natural production of Central Valley anadromous fishes over the 1967-1991 population levels. In order to achieve these objectives, approximately 18,000 tons of cleaned spawning sized gravel, and roughly 7,000 tons of larger cobble was harvested from the project area and inserted into the river, creating or improving a total of 33 riffles, and restoring fluvial geomorphic processes. Increasing the area of suitable spawning habitat should increase the abundance and condition of Chinook salmon and steelhead trout by reducing the effect of density dependent factors such as redd superimposition and by decreasing the area of habitat available for predatory fish. All in river work associated with the Lover's Leap Restoration Project was completed in September 2007. Immediately following in-river construction, nearby floodplain habitat, temporary access routes and areas of disturbed river bank were seeded with perennial and annual rye grass mix, and dry pasture mix designed for local climate conditions.

Lancaster Rd. Floodplain Restoration Project (Cramer Fish Sciences 2012)

The Lancaster Rd. project reclaimed approximately 640 ft (195 m) of remnant side channel, allowing it to flow at the 1.5-year inundation interval (i.e., 575 cfs). In addition, three cross-channels were created on the existing alluvial bar to function at higher river flows (i.e., 3- and 5-yr inundation intervals), increasing available habitat, and connecting the reclaimed side channel and floodplain to the main river channel. Approximately 800 yd^3 (~612 m^3) of material was excavated from the side channel, screened, and sorted on-site. Appropriate sized material for juvenile salmonid rearing habitat was placed back in the side- and cross-channels. The excess fine material was used to enhance portions of the disturbed floodplain to aid with revegetation.

Honolulu Bar Floodplain Restoration Project (FishBio LLC 2012)

The Honolulu Bar Floodplain Restoration Project was designed to create or restore several aquatic and riparian habitat elements in the Stanislaus River including 2.4 acres of floodplain habitat on the inside edge of a mid-channel island, 0.7 acres of floodplain bench in the south side of the river upstream of the mid-channel island, 0.4 acres of spawning riffle in the river adjacent to the mid-channel island, 3.85+ acres of native vegetation, and increased frequency and duration of flow connectivity in one mile of side channel habitat. Objectives of the Project include (1) restoring seasonally inundated floodplain habitat, (2) restoring year-round rearing habitat, (3) addressing an existing adult stranding issue, (4) increasing usable spawning habitat area, (5) increasing hiding cover, velocity refugia, habitat complexity, and instream habitat types, and (6) restoring native vegetation.

SEP Evaluation of the Conservation Measure

Evaluation Team

Lead Author:	John Wooster (NMFS)
Support Authors:	Julie Zimmerman (USFWS), Ramon Martin (USFWS)
Reviewer:	Josh Israel (USBR)
Workshop Participants:	This conservation measure was discussed by the entire group in concert with conservation measure 06. Ron Yoshiyama (UC Davis on behalf of SFPUC), Rene Henery (Trout Unlimited), Josh Israel (USBR), Alison Weber-Stover (Bay Institute), (NMFS), Andrea Fuller (SJTA), Michael Martin (Merced River Cons. Comm), John Cain (American Rivers), Jeanette Howard (TNC), Eric Ginney (ESA - facilitator), Bruce DiGennaro (Essex Partnership - facilitator), Sean Maguire (Kennedy/Jenks - notes), and Jessica Olson (ESA - notes).

Date of Evaluation Workshop; time CM was evaluated

April 10, 2013; 2:30 pm

Modifications to the Conservation Measure

- **Action:**
  - Restore ~~at least~~ 100 acres of floodplain and side channel habitat in the Ripon to Knights Ferry reaches that will inundate more frequently (~~e.g., at flows ranging from 250 to 1500 cfs).~~
- **Approach:**
  - Side channels will be designed to inundate annually (even during critically-dry years) during spring flows and will not be perennially inundated. ~~at flows ranging from 250 to 1500 cfs, and it is assumed this will occur annually~~. This is intended to correspond to the spring pulse that occurs from the RPA, and lasts about 3 weeks (exact magnitude of flow is still TBD based on future hydrologic analysis).
  - (Added) Floodplain restoration includes cut and fill to lower elevation of existing floodplain and raise channel surface on existing bed to create seasonally inundated habitats
  - ~~Floodplain inundation is initiated at 1,250 cfs in the Ripon to Jacob Meyers and in the Orange Blossom to Knights Ferry reaches~~.

Clarifying Assumptions

- Assumes that sites are approximately 2.5 to 5 acres in size (20 to 40 sites, dispersed through the reach) and that 70% is cut and fill features and 30% is side channel.
- Assumes there is sufficient available sites to construct 20 to 40 projects.
- Assumes that each project design will provide suitable habitat design – depth, velocity and cover. Also assumes that each project will be designed with appropriate hydraulic connectivity during both inundation and desiccation
- Assumed that flow would be provided in order to meet the inundation frequency as described under the approach, i.e. whether sufficient flow would exist for restoration projects to function properly was not evaluated or considered under "certainty" scores

Notes taken During Evaluation Workshop

- Non-flow action assumes regular operational flows.
- Looking at macro-invertebrate monitoring to look at density – pre project and post project.
- Question as to how much linear feet of side channel habitat will be created with 100 acres of habitat.
- Objective – has abundance, life history diversity – might need a stability component. Don't measure doubling every year either.
- Significant debate as to whether this action should be scored a large or small scale action, particularly when compared to CM 1 gravel augmentation (which was scored large-scale despite restoring a much smaller area and producing a smaller percent increase in relevant habitat, i.e. spawning habitat for that measure.
- These are not really floodplains per say, because of the limitation of size (100acres in total) we are talking about off main channel habitats (channel margins and side channels.

Scale of Action: Medium

(note: this limits the magnitude scale to a maximum score of 3)

Rationale:
Adding 100 acres of off-channel habitat, with 20 to 40 sites. The current estimate for available juvenile rearing habitat is 33 acres based on a reach scale extrapolation of WUA curves (USBR 2012); much of this habitat is likely channel margins rather than off-channel habitat proposed in this measure. The number of sites should increase habitat complexity throughout the longitudinal distribution in the Stan, but the total area (100 acres) is too small to make it a large scale action.

Evaluation Summary

Potential Positive Ecological Outcome(s)

Outcome P1: Increased habitat extent and connectivity

Clarifying Assumptions:

- (see clarifying assumptions above pertaining to sufficient sites available, proper habitat and hydraulic design)

Scientific Justification:

- **Magnitude #2/3:** Potential for significant increase in rearing habitat from 33 acres existing to 133 acres since many additional patches will be created. This is likely to influence the population productivity (via increased carrying capacity of juveniles), spatial distribution, and life history diversity). However, we do not know if adding 100 acres is significant at the population level.

- **Certainty #3:** Relatively high certainty that side channels can be designed at an elevation that will inundate at the target flows (i.e., it is just a stage-discharge relationship within the design) and designed with suitable habitat criteria. Some uncertainty that the created side channel will remain connected through time, i.e., sediment deposition and/or degradation can isolate or alter connectivity through time, or even over one flow event.

Outcome P3: Additional rearing habitat

Clarifying Assumptions:

- (see clarifying assumptions above pertaining to sufficient sites available, proper habitat and hydraulic design)

Scientific Justification:

- **Magnitude #3:** Significant increase in rearing habitat from 33 acres existing to 133 acres since many additional patches will be created. This is likely to influence the population productivity (via increased carrying capacity of juveniles), spatial distribution, and life history diversity).

- **Certainty #3:** Relatively high certainty that side channels can be designed at an elevation that will inundate at the target flows (i.e., it is just a stage-discharge relationship within the design) and designed with suitable habitat criteria. Some uncertainty that the created side channel will remain connected through time, i.e., sediment deposition and/or degradation can isolate or alter connectivity through time, or even over one flow event.

Outcome P4: Potential for expanded spatial distribution into formerly (historically) occupied habitat areas

Clarifying Assumptions:

- Assumes the "historical" habitat refers to lateral extent as opposed to longitudinal expansion

Scientific Justification:

Magnitude: #3
Existing condition of incised channel with limited lateral connectivity; project represents increase at multiple habitat patches and have expected sustained minor population effect.

Certainty: #3
Relatively high certainty that side channels can be designed at an elevation that will inundate at the target flows (i.e., it is just a stage-discharge relationship within the design) and designed with suitable habitat criteria. Some uncertainty that the created side channel will remain connected through time, i.e., sediment deposition and/or degradation can isolate or alter connectivity through time, or even over one flow event.

Outcome P7: Increased establishment of woody riparian vegetation providing shaded channel habitat, increased channel margin complexity, and export of large woody debris (LWD)

Clarifying Assumptions:

- Assume the inundation flow regime includes a recession limb that is conducive to riparian vegetation germination.

- Assumes projects will include riparian vegetation planting and will include irrigation to support riparian vegetation at approximately 80% survival level and will be monitored for 3 to 5 year window post-project completion. If 80% survival is not achieved, design will include replanting of riparian vegetation.

Scientific Justification:

- **Magnitude #2/3:** The benefits of a healthy riparian community for healthy riverine ecosystems are well established (e.g., Gurnell et. al 2005). However, when we consider the entire river section these 100 additional acres will be within, the effect of woody riparian habitat or additional large wood from this 100 additional acres within 58.4M of Stanislaus channel could be expected to sustain a limited effect due to local (and limited) spatial and temporal habitat improvement.

- **Certainty #3:** See assumptions above, but designs are assumed to include substantial riparian vegetation components and level of protection that if plantings fail they will be replanted until successful. Without flow and riparian design assumptions, certainty would be lower. The physical processes associated with Central Valley alluvial rivers that control regeneration and survival of riparian vegetation are fairly well understood and include flooding, stream meander, sediment scour, and deposition (e.g., Stella et. al 2006).

Outcome P8: Increased establishment of emergent vegetation providing high quality rearing habitat

Clarifying Assumptions:

- Assumed emergent vegetation is referring to grasses, cattails, tule reeds, etc. and not more riparian species such as willows.

Scientific Justification:

- **Magnitude #1/2:** With limited inundation time, the primary "high-quality" rearing habitat is expected to be more from favorable hydraulic habitats as opposed to emergent vegetation. Seasonally connected side channels and channel margins should not be expected to provide more than a little effect concerning emergent vegetation to support rearing habitat.

- **Certainty #2/3:** Uncertainty revolves around just how much emergent vegetation will result from limited inundation time. Certainty and magnitude could improve with additional design detail, which could possibly indicate that emergent vegetation was integral part of design.

Outcome P10: Increased delivery of readily-suspendable sediments providing increased turbidity downstream, improved habitat conditions, and greater feeding success, and reduced predation

Scientific Justification:

- **Magnitude #2:** Expected supply of readable suspended sediment at restoration sites is low, and overall restoration area is small (100 acres) when considering sediment source area, hence overall the action is not expected to provide a substantial amount of additional suspended sediment and is anticipated to only impact a limited to small fraction of the population.

- **Certainty #2:** Uncertainty revolves around quantity of available / additional suspended material at action sites.

Outcome P12: Increased production and local availability of aquatic food resources (POM, phytoplankton, zooplankton, small fish, etc)

Scientific Justification:

- **Magnitude #2/3:** Side channels play an important role in riverine food webs since they provide greater channel margin habitat for input of terrestrial food resources typically, not aquatic food resources. This is due to the very short residence times in these flows through habitats, which limits phytoplankton and zooplankton production. Additionally, the input of POM is immediate and is limited to only when the areas actively inundated, and these benefit diminish rapidly once the POM is exported. While side channels may contain channel margin habitats, which are spawning areas for native fishes the increase in production is limited due to these areas being wetted when fish are spawning, which is typically late winter and spring. Due to the 100 additional acres being a very limited habitat of channel margin along the 58.4M section of river, the magnitude of increased production is consider Low.

- **Certainty #2:** Uncertainty depends on length of inundation, and whether it is limited to 2-3 weeks. Additional uncertainty revolves around how productivity is linked to duration of inundation.

Outcome P13: Increased production of terrestrial invertebrates put into the aquatic ecosystem for rearing covered fish

Scientific Justification:

- **Magnitude #3:** Side channels increase channel margin and provide for increased riparian cover. This additional 200 acres of channel margin habitat will increase production of terrestrial invertebrates for rearing covered fish. Although this area represents only a small fraction of the close to 100M of channel margin habitat in the section of river this CM will be implemented in, it is likely to affect production on multiple patches of habitat. Thus, increased production is expected to have a sustained minor population effect for a Medium outcome.

- **Certainty #3:** Not as tied to duration of inundation as P12, as soon as wetted up terrestrial food becomes available.

Outcome P14: Food resources produced on the restored habitat will be exported and contribute to food availability in downstream aquatic areas. (Note: food resources could include organic carbon, phytoplankton, zooplankton, and other organisms)

Scientific Justification:

- **Magnitude #2/3:** Evaluated primarily for food availability for downstream, incised reaches on Stanislaus. Mixed magnitude score, in part, due to missing information on where and how within the relatively long reach the restoration sites will be distributed.

- **Certainty #2:** Uncertainty revolves around how much biomass and carbon will be produced with the three weeks of inundation on 100 acres and the scale of food export relative to downstream reaches. Uncertainty also revolves around the longitudinal distribution of restoration sites, which will affect where and how much food is distributed back into the channel.

Outcome P15: Increased or decreased nutrients (NPK, etc)

Scientific Justification:

- **Magnitude #2:** Low elevation (i.e. not up on traditional floodplain) that are primarily gravelly type reaches, not nutrient rich soils.

- **Certainty #2:** Limited information known on availability, quantity, and quality of available nutrients in restoration areas.

Outcome P17: Reduced predation mortality (i.e. due to striped bass, black bass, and other non-native predatory species)

Scientific Justification:

- **Magnitude #2/3:** Juveniles would be larger (growth) so some increased survival based on health and swimming speed to avoid predators. However, only a small portion of juveniles will be able to use the 100 additional acres. The limiting factor of juvenile rearing habitat remains since this CM is limited in area. Thus, the reduced predation mortality within the small fraction of the population that benefits from the 100 additional acres suggests the outcome is expected to sustain a limited fraction of the population with a score of Low.

- **Certainty #2:** Baker and Morhardt (2001) reduce predation mortality due to swimming speed. The quantity of habitat compacted to the area in will be implemented in suggested reduced predation mortality is likely unconstrained by undertaking the CM.

Outcome P18: Increased survival of out-migrating juveniles by providing migration route with lower predation

Scientific Justification:

- **Magnitude #2:** Still have to migrate through predator areas, juveniles would be larger (growth) so some increased survival to avoid predators. 100 acres of new channel along 58.4M of channel will likely not provide sufficient alternate route lengths to reduce exposure to predators.

- **Certainty #2/3:** Benefits of avoiding predators due to larger size are documented (Baker and Morhardt 2001), and predator issues in lower Stanislaus and San Joaquin rivers are documented. However, the size of the CM constrains the length of alternate routes, which are no long enough to bypass lower Stanislaus predator issues.

Outcome P20: Increase juvenile Chinook salmon size at emigration

Scientific Justification:

- **Magnitude #3:** Expected sustained minor population effect on multiple patches of habitat.

- **Certainty #3:** Benefits of floodplain and off-channel rearing are well documented (e.g., Sommer et al 2001).

Outcome P21: Increase life history diversity (or diversity of outmigration)

Scientific Justification:

- **Magnitude #3:** Expected sustained minor population effect on multiple patches of habitat. Action is expected to create diversity in size at outmigration as well as influence timing of outmigration due to providing additional rearing habitat with timing that would vary based with timing of inundation (expected to fluctuate somewhat with water year type).

- **Certainty #3:** Benefits of floodplain and off-channel rearing are well documented (e.g., Sommer et al 2001).

Potential Negative Ecological Outcome(s)

Outcome N1: Increased habitat for non-native predators/competitors to covered species

Clarifying Assumptions:

- Certainty is based on the ability to design a project that has low habitat suitability for predators.

Scientific Justification:

- **Magnitude #2**

- **Certainty #3:** Reasonable literature to identify what habitat criteria predators prefer / avoid (e.g., KDH 2008)

Outcome N4: Increased stranding or entrainment mortality

Clarifying Assumptions:

- Certainty is based on the ability to design a projects that have a low stranding risk and appropriate hydraulic connectivity during desiccation.

Scientific Justification:

- **Magnitude #2:** Increased stranding risk is expected to be low with proper design and construction of restoration sites.

- **Certainty #3:** Relatively high certainty that restoration sites can be designed to limit stranding risk. Uncertainty is primarily related to how projects might evolve through time with channel shifting, potential degradation, and/or sediment deposition that could influence connectivity and change stranding risk relative to original design.

Data Gaps, Key Uncertainties, New Ideas, and Suggestions for Future Planning

Data Needs:

- Need more information on the area and number of potential restoration sites. Need to know longitudinal distribution and spacing of restoration sites.
- Need adequate topography and modeling information to assess flow connectivity and stranding risk.

Key Uncertainties and Research Needs:

- RH – if we don't define how much floodplain habitat is needed first then everything is arbitrary to some extent. It would help to say historically there is X% roughly, and currently we have X% with a target of Y%.
- Need additional information pertaining to duration of inundation and quantity and quality of primary productivity (i.e. food resources). In other words how much production occurs after 2 or 3 weeks?

Important New Ideas or Understandings:

None.

Potential CM Re-configurations to Increase Worth /Decrease for Implementation

CM should start with determining the potential number, total area, and longitudinal distribution of potential restoration sites within the target reach, as opposed to arbitrarily assuming that 100 acres within 20 to 40 individual sites will be restored.

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Appendix A: Summary Tables Organized by Outcome

TABLE A1
OUTCOMES

	Standarized Outcomes for Stanislaus River SEP	Scoring	
Standard Outcome Code	**Outcome (brief descriptor)**	**Magnitude**	**Certainty**
Habitat - Spatial Extent			
P1	Connectivity of habitat	2/3	3
P3	Rearing	3	3
P4	Expand Spatial Distribution	2	3
Habitat Quality			
P7	Shaded Channels /Channel Margin/LWD	2/3	3
P8	Emergent Vegetation	1/2	2/3
P10	Suspended Sediments	2	2
Food			
P12	Increased Local Aquatic Primary and Secondary Production	2/3	2
P13	Increased Terrestrial Invertebrates	3	3
P14	Food Export	2/3	2
P15	Nutrients	2	2
Mortality			
P17	Reduced Predation	2/3	2
P18	Route for Out-Migration	2	2/3
Size			
P20	Increase juvenile chinook salmon size at emigration	3	3
Life History			
P21	Increase life history diversity (or diversity of outmigration)	3	3

TABLE A2
NEGATIVE OUTCOMES

Standarized Outcomes for Stanislaus River SEP		Scoring	
Standard Outcome Code	Outcome (brief descriptor)	Magnitude	Certainty
Habitat - Spatial Extent			
N1	Habitat for Predators/Competitors	2	3
Mortality			
N4	Increased Stranding	2	3

Standard Outcome Code	Outcome (brief descriptor)	Worth		Risk		Worth		Risk	
		Grade	Numeric	Grade	Numeric	Grade	Numeric	Grade	Numeric
Habitat - Spatial Extent									
P1	Connectivity of habitat	High	3			Med	2		
P3	Rearing	High	3			High	3		
P4	Expand Spatial Distribution	High	3			High	3		
N1	Habitat for Predators/Competitors			Med	2			Med	2
Habitat Quality									
P7	Shaded Channels /Channel Margin/LWD	High	3			Med	2		
P8	Emergent Vegetation	Med	2			Low	1		
P10	Suspended Sediments	Med	2			Med	2		
Food									
P12	Increased Local Aquatic Primary and Secondary Production	Med	2			Med	2		
P13	Increased Terrestrial Invertebrates	High	3			High	3		
P14	Food Export	Med	2			Med	2		
P15	Nutrients	Med	2			Med	2		
Mortality									
P17	Reduced Predation	Med	2			Med	2		
P18	Route for Out-Migration	Med	2			Med	2		
N4	Increased Entrainment			Med	2			Med	2
Size									
P20	Increase juvenile chinook salmon size at emigration	High	3			High	3		
Life History									
P21	Increase life history diversity (or diversity of outmigration)	High	3			High	3		